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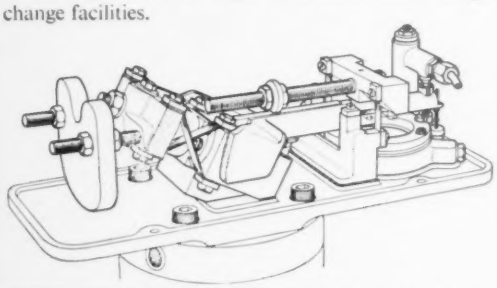

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Hon. Editor: PROFESSOR F. H. GARNER, O.B.E., PH.D., F.R.I.C.
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Editor: GEORGE SELL

Vol. 8, No. 87 **March 1954**

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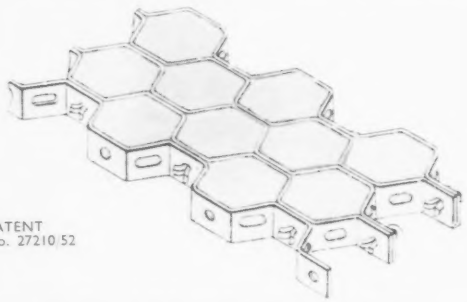

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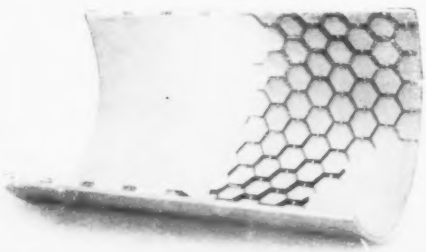

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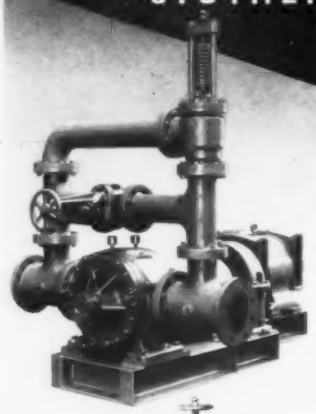
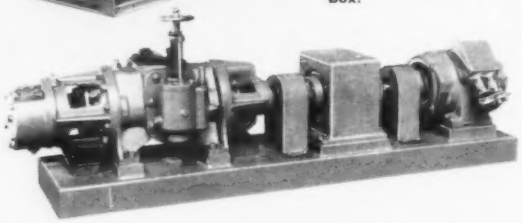


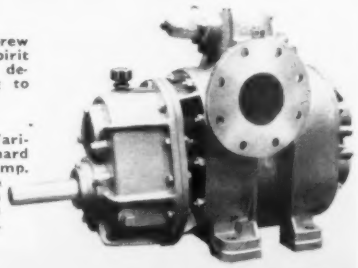
(Left)
Positive Acting Rotary Displacement Pump for the handling of Molasses and viscous fluids, electrically driven through totally enclosed Reduction Gear Box.

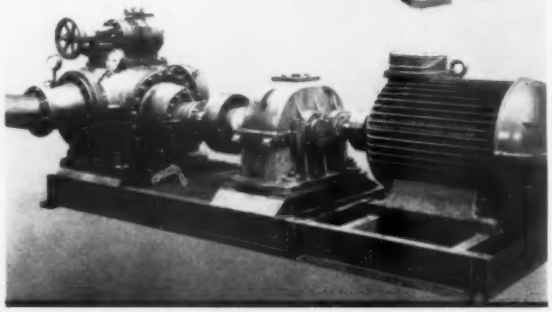
(Below)
Positive Acting Screw Displacement Spirit Pump, electrically driven through Wall Box.



(Right)
Positive Acting Screw Displacement Spirit Pump specially designed for fitting to Road vehicles.

(Below)
Positive Acting Variable Output Guinard Rotary Piston Pump, electrically driven through Reduction Gear Box, for Oils of varying viscosity.





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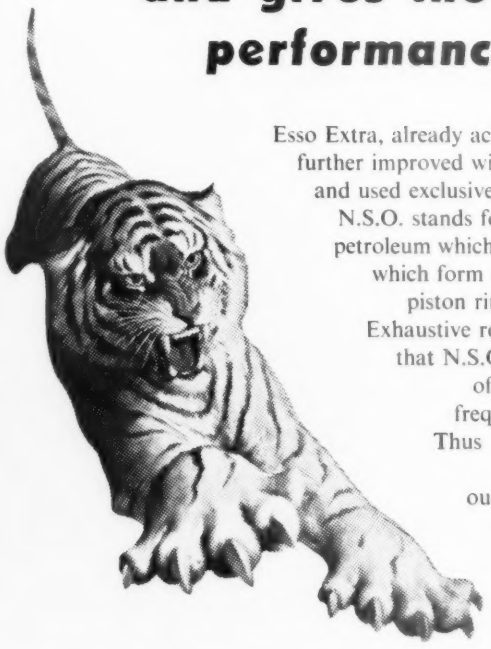

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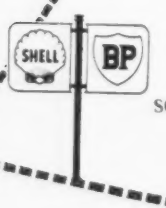

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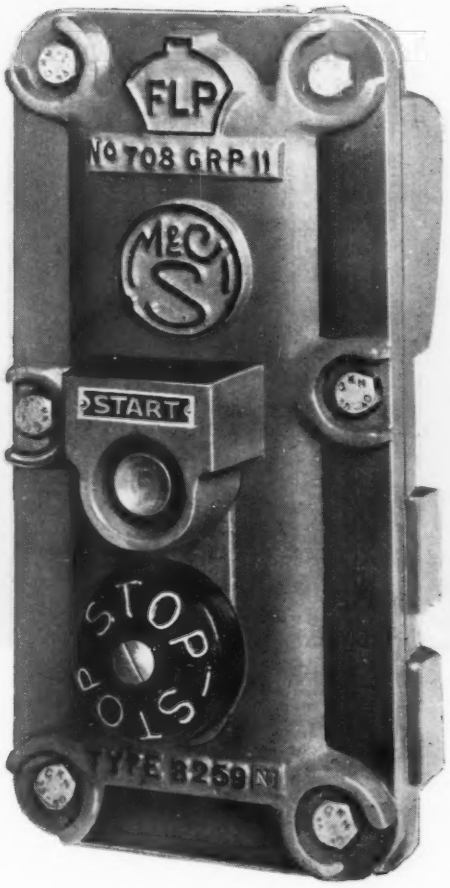

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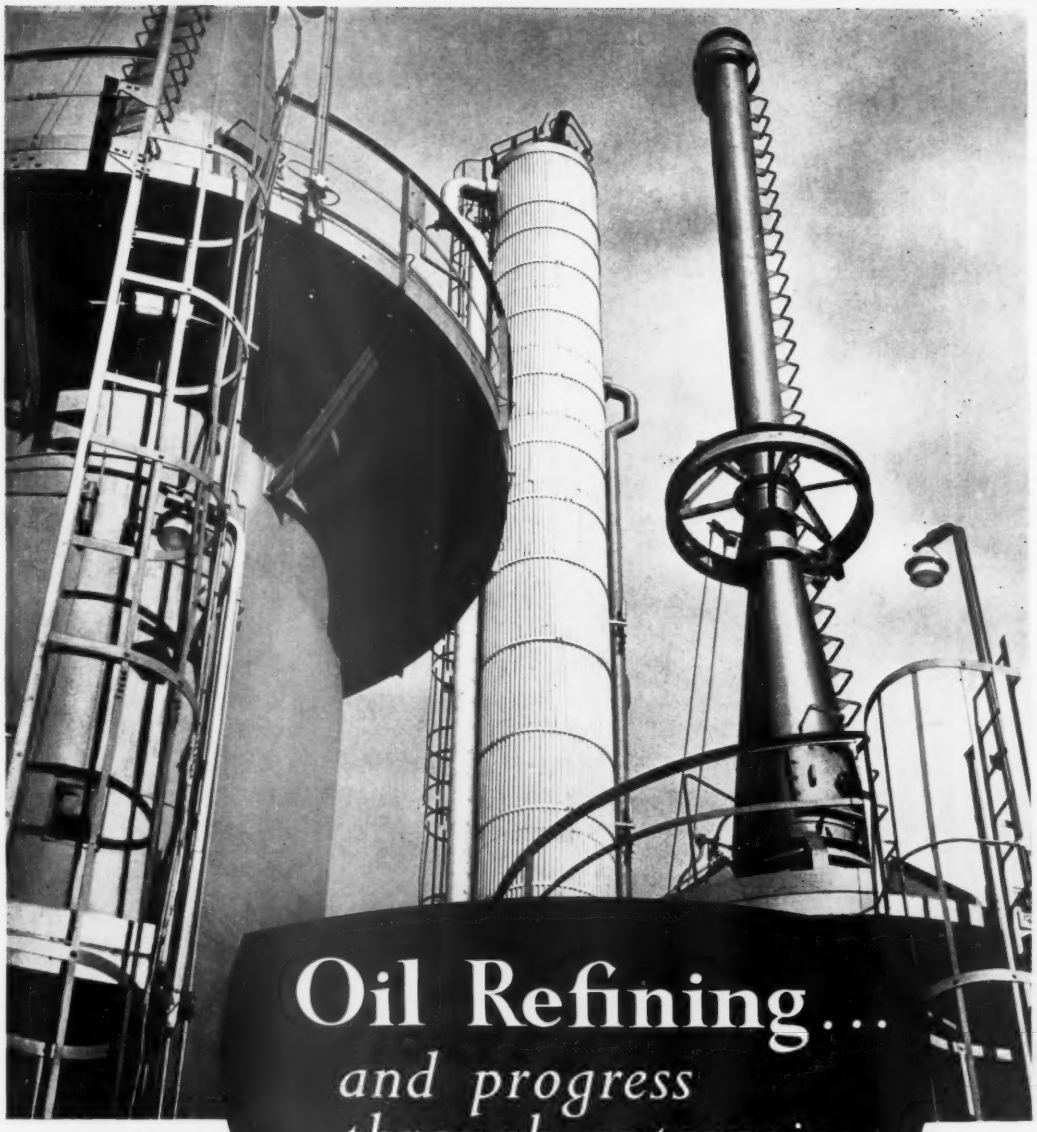

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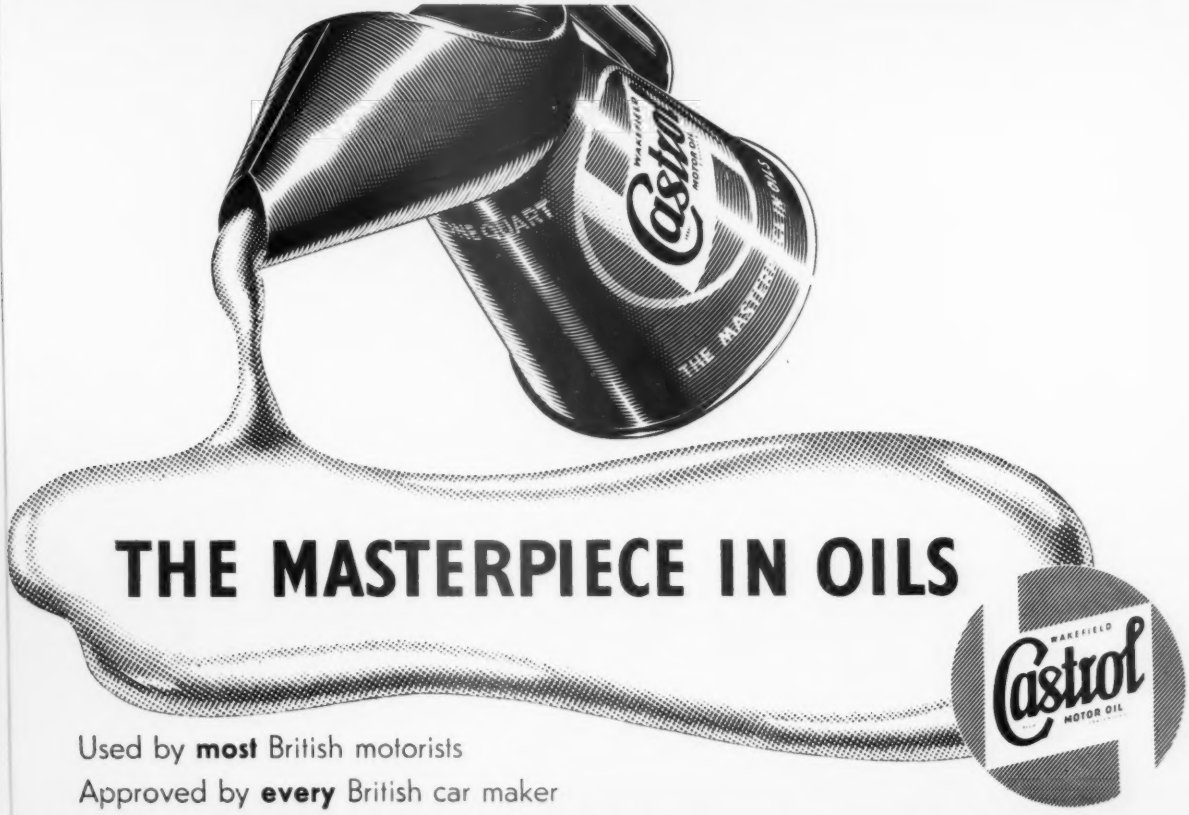

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Strategic Aspects of Oil Supply and Demand*

By W. E. V. ABRAHAM, C.B.E. (Member)

The tonnage of oil products—mainly aviation and motor spirits—required in war theatres during the second world war was about a hundred times as great as in the 1914-18 war and the resultant world requirements (military and civil but excluding axis-controlled countries and oil produced in Russia) reached in 1945 a peak figure of about one million tons per day, made up very roughly as follows:—

	Tons
Aviation spirit	100,000
Motor spirit	300,000
Kerosine	100,000
Fuel oils	400,000
Other products (including "loss")	100,000

World production now in 1953 is about 1·75 million tons a day, but in the early days of the war a million tons a day must have seemed enormous and in order to meet requirements four main achievements were necessary:

(*a*) Crude oil production had to be increased by about a third from its pre-war figure of something like three-quarters of a million tons per day. This meant greatly intensified drilling programmes, mainly American.

(*b*) Refinery capacity had to be similarly increased. This was done not so much by building new refineries (though this also was necessary) as by making fuller use of existing refineries, treating all Allied refinery capacity outside of Russia as a single whole, and putting each individual refinery to the best possible use for the common good.

(*c*) Special arrangements had to be made for particular products, and above all for aviation spirit, the output of which had to be increased no less than ten times, and the quality of which was increased from 87 to 100 octane. This combination of improved quality with a tenfold increase in quantity was an outstanding achievement, calling for many completely new plants. Most of the increase was again in America but we have every right to be proud of the British contribution too, especially at Abadan.

(*d*) Lastly, certain large-scale transportation adjustments must be mentioned. Of these the most important were:

(*i*) The consequence of the closing of the Mediterranean in 1940, when we could no longer afford the long haul from the Persian Gulf round the Cape of Good Hope to the United Kingdom, and had to draw supplies from Venezuela instead. As a result, Abadan had to be shut down below what it could produce—only to regain its importance not long afterwards when Japan denied us the oil of the Dutch East Indies, British Borneo, and of Burma.

(*ii*) The action of American oil interests, before America entered the war, in carrying oil from Venezuela, Trinidad, etc., to New York, where our tankers could pick it up for the much shorter journey to the United Kingdom.

(*iii*) The arrangements made in the U.S.A., first by rail tank-car and barge, and later by the laying of enormous trans-continental pipelines, to relieve American tankers from the work of carrying petroleum products from the Gulf of Mexico to the Atlantic seaboard, and thus free them for the common effort of supplying the United Kingdom and the theatres of war as they developed.

These arrangements were made possible only by the utmost goodwill on the part of American oil interests before America entered the war, and thereafter by closest co-operation between the oil interests—of all kinds—of the United Kingdom and the U.S.A. Even then no transportation adjustments would have won the day had it not been for an intensive tanker building programme, mainly in the U.S.A., which left the Allies at the end of the war, in spite of very heavy losses, with appreciably more tanker tonnage—and faster tonnage—than at the beginning of the war. Another important factor was the very big storage space which had been created in the United Kingdom before the war. This reservoir, with excellent fast-working taps both in and out, and backed up later by over 1000 miles of pipeline in the United Kingdom alone, gave a flexibility to our supply arrangements without which some of our transportation crises could not have been surmounted. As an example, the North African landing was fuelled largely on stocks from the United Kingdom.

World Oil Position Today

What is possible in time of war depends largely, though of course not altogether, on patterns developed in time of peace, and rather than express my own opinions as to what might happen in particular circumstances I give you the best general picture I can of the world position today and leave you to draw your own conclusions. The pattern of oil movement is determined essentially by the inter-relation of oil production and oil consumption, and the first table sets out where the oil is produced and where it is consumed. The figures are in rough percentages of the world total, which is now 1¾ million tons a day, and increasing every year.

TABLE I

	Production *Per cent*	*Consumption* *Per cent*	*Proved Reserves* *Per cent*
U.S.A.	52	56	25
South America	15	7	10
Middle East	18	2	50
U.S.S.R.	9	9	10
Rest of the World	6	26	5
	100	100	100

World Production

The figures for oil production illustrate strikingly how unequally this production is divided. U.S.A. produces more than half of the total. The next biggest area is the Middle East, that is of course, the Persian Gulf areas plus Iraq. Then the Caribbean (mainly Venezuela) in South America. Then Russia, and after these the rest of the world with only about one-twentieth of the world's total. When we consider that the "rest of the world" includes such places as Mexico, Canada, all Europe outside the Iron Curtain, Pakistan, India and Burma, Indonesia, and British North Borneo we cannot help being amazed at the outstanding productiveness of the first four on the list, especially U.S.A., the Caribbean, and the Middle East.

*An address to the Oil Industries Club, November 1953.

World Consumption

Now consider the consumption figures. If it was surprising that U.S.A. produces more than half of the world's oil, her ability to consume an even greater proportion is still more surprising. U.S.A., with a population of about 150 million people, consumes no less than a million tons of oil a day—well over half of the world's oil—and the remaining 2000 million people do the best they can with what remains. This is a measure of the extent to which U.S.A. runs on oil, in comparison with other countries. Speaking very roughly U.S.A. runs 65 per cent on oil and natural gas and 35 per cent on coal, whereas U.K. runs 85 per cent on coal and only 15 per cent on oil, and the difference is of course still more striking in relation to many other countries. South America consumes only about 7 per cent of the world's total and there is thus a big surplus, equal to one-twelfth of the world's total, available for export to other countries. The surplus from the Middle East is even greater, because of the relatively very small consumption in that area. About one-sixth of the world's total production is here available for export and use elsewhere. Broadly speaking Russia, including her satellites, consumes just about what she produces, and the "rest of the world" is left with a deficit of 20 per cent of the world's total.

World Movement of Oil

The pattern of international oil movement is at once clear from these figures. It consists essentially in the movement of the big surpluses from the Middle East and the Caribbean to make up the appreciable deficit in U.S.A. and the enormous deficit in the rest of the world. More than half of the very big deficit of the rest of the world is in Western Europe and we can therefore expand our general statement slightly by saying that international oil movement consists mainly in movement of the Caribbean surplus largely to U.S.A. and in part to other places (including Western Europe), and movement of the main part of the big Middle East surplus to Western Europe, and the remainder to other parts of the world.

That is the picture as it is to-day. The main changes which have been and are taking place in this picture are:—

(*a*) production from the Middle East has been rapidly increasing (in spite of the Persian setback) and will certainly continue to increase,

(*b*) the U.S.A. deficit, which began only a few years ago, is increasing year by year and will almost certainly continue to increase,

(*c*) up to a certain point this increase in the U.S.A. deficit will be met mainly by increased imports from the Caribbean,

(*d*) the proportion of Caribbean oil available for export to Western Europe and elsewhere will become increasingly less, and

(*e*) this will in turn be compensated by increased supplies from the Middle East.

As an illustration of how this tendency has affected and will affect supplies to U.K. it is worth noting that in 1938 U.K. got more than two-thirds of her oil supplies from the West and less than one-third from the Middle East whereas these proportions are now reversed, and our expectation must be that in another five years or so U.K. will be getting 95 per cent or more of her supplies from the Middle East. This change over to reliance on the Middle East would have been even more rapid if it had not been for the breakdown in Persia. In particular the loss of Abadan's refining capacity has meant that U.K., in common with almost all countries of the Eastern hemisphere, has had to rely on the Western hemisphere for large quantities of refined products. Even if Abadan remains closed that gap in refining capacity will soon be made good by refineries at Aden and elsewhere.

World Reserves of Oil

The two main tendencies noted above, namely the rapid increase in Middle East production and the steady increase in the U.S.A. deficit, are both due fundamentally to the proved reserves of oil held in those countries. No one can hope to estimate exactly the so-called "proved reserves" of any country but there is fairly general agreement that the proved reserves of the world (as opposed to the much greater "probable reserves") are some 16,000 million tons, amounting to some 25 years' supply at present rates, and that the distribution, in very rough figures, is somewhat as in Table I.

This again emphasizes the inequality of world oil distribution, and incidentally shows that the "rest of the world" is unfortunately no better off in respect of proved oil reserves than in respect of present day production. It shows also that U.S.A. has nothing like sufficient proved reserves to allow it to continue to be self-supporting at its very high consumption level, as it was until only a few years ago, and that is the real reason why U.S.A. has in recent years become a net and increasing importer of oil. South America, with 10 per cent of the world's proved reserves, also seems to be over producing whereas both Russia and the "rest of the world" are producing in almost exact accordance with what their proved reserves would justify.

The Middle East

Above all, these estimates of proved reserves underline again the quite outstanding position of the Persian Gulf area which contains fully half of the world's proved reserves, and probably contains not much less than half even without Persia. Comparison of Columns I and III of Table I shows that the Middle East is the only one of the main producing regions which is grossly under-producing in relation to its proved reserves, and the only one therefore whose proportion of the total production of the world is almost certain under peace conditions progressively and rapidly to increase. This brings me to my last point. We have seen already that the exportable surplus from the Middle East is double that from the Caribbean, but even that is not the full story, since the Caribbean surplus is largely earmarked to meet the increasing deficit of U.S.A. This Caribbean surplus, expressed as a percentage of the world's total production, is unlikely to increase and it follows that as the U.S.A. deficit increases a stage will be reached when the whole of the American Continent, North plus South, will on balance (and in spite of Canada's progress towards self-sufficiency) produce only as much as it consumes. No one can say exactly when this will happen, but it may well be within five years, depending largely on American production policy. Even to-day the net exportable surplus of the Western Hemisphere, from Canada to the Argentine, is less than 4 per cent of world production, whereas only five years ago the corresponding figure was nearly 10 per cent. Before very long there will be no net surplus, and when that time comes—quite possibly as I have said within five years from now—the Middle East will be the *only* big source of surplus for exportable production with which to feed the rest of the world. Indonesia and British North Borneo will remain important sources in the Far East, but quantitatively they are and will be minute in relation to the enormous Middle East surplus. The more one looks at it therefore the plainer it becomes that whatever emergency arrangements might with difficulty—and I emphasize those two words—be made to keep U.K. and Western Europe supplied during a temporary stoppage, there is no long term alternative now in sight for the world, over the next ten or twenty years, to these prolific Middle East resources.

Other Sources of Oil

In conclusion I would like to emphasize three things. First, I have dealt only with crude oil which can be produced in oil wells as such. There are many other ways of getting oil, for example from coal, or oil shale, or the Athabasca tar sands.

but all of these other sources suffer from the fundamental disadvantage that in order to get the oil, which is really energy, a great amount of energy, namely in the form of heat, has first to be put in. Secondly, there is nothing static about oil or the oil industry, and the less important products of today may be the more important ones of tomorrow. It is not so very long since petrol was regarded as a waste product of kerosine manufacture, and kerosine, after a period of minor importance, has now come into its own again as a fuel for jet aircraft. And lastly, I have not been able even to refer to a host of so-called "chemicals," including acetone, plastics, and even alcohol, which can now be made from petroleum, and just as I have ventured no guess as to when and how the atom will become an important source of energy so I will make no attempt to forecast what products, and in what proportions, and whether for peace or war—but let's hope for peace—we shall then be making from this wonderful mineral crude oil.

★ ★ ★

COUNCIL COMMENTARY

The first Council Meeting of the New Year took place on 13 January, the President being in the chair.

Mr Gibson opened the meeting with a statement on the choice of a President for 1954/55. A small committee consisting of the President, the Past-Presidents, and the honorary officers of the Institute, has been giving this matter some thought, and has decided unanimously to recommend that Colonel S. J. M. Auld be invited to accept the Presidency for the next Session. This recommendation was endorsed whole-heartedly by Council. Colonel Auld is well-known to many members of the Institute and has, for many years, taken a leading part in Institute affairs. He is a Past-President, having served a term of office as President during the years 1937 to 1939.

Mr G. H. Coxon has agreed to serve as Honorary Treasurer for 1954/55. He has been ill for some weeks, but it is understood that he is making a good recovery and will, it is hoped, soon be active once again.

Some discussion took place on the design of the Eastlake Medal, the first award of which is to be made to Mr Coxon. A very attractive design, showing the Institute crest on one face, was approved. It was decided that this medal should be of bronze and that a hand-cut die should be made so that the best reproduction possible could be obtained.

The Minutes of the Research Committee were presented and discussed. The Hydrocarbon Research Group has eight contributory member organizations—Anglo-Iranian Oil Co. Ltd., Esso Development Co. Ltd., I.C.I. Ltd., Ministry of Supply, Monsanto Chemicals Ltd., National Coal Board, The Shell Petroleum Co. Ltd., and Trinidad Leaseholds Ltd.—giving an annual income of £8000. Expenditure for the year amounted to £8244 of which £7872 10s was made up of direct grants and honoraria to Universities. With the credit balance at the beginning of the year, this leaves a credit balance at the year end of £1418. There are three panels of this group:—

(*a*) Spectroscopic Panel;
(*b*) Mass-Spectrometry Panel;
(*c*) Hydrocarbon Chemistry Panel.

An application to form a branch in Australia was unanimously approved. The branch activities will, in the main, be confined to Melbourne and Sydney, at least for the next few years, with Melbourne as the administrative centre. Negotiations for the formation of an Irish branch have not progressed and it is doubtful whether such a branch will be formed this year.

Arrangements for the Summer Meeting are going well, but so far applications have not reached the level existing at this time last year. Arrangements for the technical programme are well advanced and authors have now been agreed for all the papers.

THE VOICE OF THE PAST

The Crystal Ball

The oil supply the world over is increasing with a marvellous rapidity. Country after country, district after district, is being exploited for oil and the more one seeks the more one finds.

It is the coming source of power; one might almost be led to say that the next age would be the age of oil.

. . . This is not vain imagining; the statements are actual fact and should do something towards reassuring those who look with some apprehension to the future in regard to our fuel requirements. *Petroleum Review* (now *Petroleum Times*), 1899.

Jobs Vacant

A character known only to the oil regions is the nitro-glycerine man.

As nearly all the wells were situated on hillsides, the nitro-glycerine had to be taken there in a light waggon, and anywhere from half a dozen to twenty cans were carried at a time. The slighest lurch of the waggon, or the stumbling of a horse, was apt to jar the cans and the probabilities were that they would explode. *The Pennsylvania Oilfields*, 1899.

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TRINIDAD PITCH

A Shell Photograph

In November last the Royal Photographic Society and the Institute of British Photographers held an exhibition of Photography in Industry and Commerce. Of the 237 prints displayed nine were by members of the Shell Photographic Unit. This one, by Derrick Knight, M.B.E., A.I.B.P., F.R.P.S., is entitled "Worker on the Trinidad Pitch Lake."

The Rôle of Petroleum in Modern Transport

SUMMER MEETING PROGRAMME

Arrangements for the 1954 Summer Meeting of the Institute are well advanced, and those who wish to attend this important function are advised to make application to the General Secretary if they have not already done so.

As already announced, the meeting is being held in Llandudno during the period 12-15 May. The theme of the technical sessions is "The Rôle of Petroleum in Modern Transport" and the following tentative programme indicates the nature of the topics to be discussed.

FIRST SESSION—5.45-6.45, 12 May

1. **THE TRANSPORT INDUSTRY.** By C. T. Brunner, M.A. (*Shell-Mex and B.P. Ltd.*).

A general survey of the petroleum requirements of the transport industry on land and sea and in the air.

SECOND SESSION—9.30-12.30, 13 May

2. **LAND TRANSPORT BY RAIL.** By A. S. Robertson, A.R.T.C. (*English Electric Co. Ltd.*) and G. M. Barrett, M.B.E., B.Sc., A.R.S.M. (*The Shell Petroleum Co. Ltd.*).

A review of present railway transport problems with particular reference to the fuels and lubricants available.

3. **FUEL PROBLEMS IN ROAD TRANSPORT.** By A. T. Wilford, B.Sc. (*London Transport Executive*).

A discussion of the application of gasolines and diesel fuels in road transport.

4. **LUBRICATION PROBLEMS IN ROAD TRANSPORT.** By S. E. Holmes, A.R.I.C., and H. M. White, B.A. (Eng.) (*Messrs C. C. Wakefield & Co. Ltd.*).

Road transport lubrication will be discussed and in general the paper will devote itself to road vehicle problems.

THIRD SESSION—9.30-12.30, 14 May

5. **AIR TRANSPORT FUEL PROBLEMS.** By K. E. W. Ridler, Ph.D. (*Anglo-Iranian Oil Co. Ltd.*).

Fuel requirements of various types of modern aircraft engines, including both reciprocating and jet engines.

6. **LUBRICATION OF AIRCRAFT.** By J. T. Tyson, M.C., B.Sc., Ph.D. (*Esso Development Co. Ltd.*), A. L. Parker (*Esso Petroleum Co. Ltd.*), and M. F. Hoare, B.Sc., B.A., D.Phil. (*Esso Development Co. Ltd.*).

Will deal with lubricants for aircraft engines and with various other petroleum products required for special aviation purposes.

FOURTH SESSION—2.00-4.00, 14 May

7. **FUEL REQUIREMENTS OF SEA TRANSPORT.** By John Lamb and L. Birts, B.Sc. (*The Anglo-Saxon Petroleum Co. Ltd.*).

The fuel requirements of both steam and diesel prime movers will be considered, together with recent developments in the application of heavy fuel oils for marine purposes.

8. **LUBRICANT REQUIREMENTS OF SEA TRANSPORT.** By R. B. Killingsworth, B.Sc., Ph.D. (*Vacuum Oil Co. Ltd.*).

General problems of marine lubrication will be considered in relation to engines and all auxiliaries.

FIFTH SESSION—4.00-5.00, 14 May

9. **FUTURE TRENDS IN TRANSPORT FUELS AND LUBRICANTS.** By K. C. Hunt, B.Sc. (*Esso Petroleum Co. Ltd.*).

This paper will summarize the situation as discussed in the previous papers and will include an assessment of the present position and of future trends.

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WORLD'S LARGEST TANKER AT MINA AL AHMADI

The world's largest tanker, the *Tina Onassis* left Mina al Ahmadi on 19 December with a cargo of crude oil on her maiden voyage. This tanker is not only the largest oil carrying ship in the world but is at the same time the fourth largest commercial vessel in the world being surpassed by only the two *Queens* and the S.S. *United States*. Her dimensions are 775·6 ft overall length by 95·15 ft beam and she has a deadweight tonnage of 45,700. She is larger (but very little) than the R.M.S. *Mauretania* (739 × 89.4). She only just wins her place from the *Ile de France* (763 × 91) but is quite a bit larger that S.S. *America* (663 × 90) and other well known ships of similar size. Only a few of the large fighting ships of the Royal Navy and American Navy exceed her in length and beam.

This mighty ship is owned by A. S. Onassis, world-known Greek shipowner, and is named after his wife.

It is understood that the keel of a sister ship has been laid on the same berth at the Hawaldtswerke, Hamburg, and that a third vessel of the same size is planned.

Around the Branches

FAWLEY, LONDON, NORTHERN, PERSIAN GULF, SCOTTISH, SOUTH EASTERN, SOUTH WALES, STANLOW, TRINIDAD

Fawley Branch

On 11 December 1953, members were pleased to welcome C. A. E. O'Brien of the Anglo-Iranian Oil Company, who spoke on the subject of prospecting for oil, the chair being taken by I. McCallum.

As a preface to his lecture, Mr O'Brien presented a film entitled *As Old as the Hills*, depicting in the style of Disney's coloured cartoons the origin of petroleum in prehistoric times and its subsequent agglomeration in underground geological formations. As a sequel to the film, the lecturer outlined the main features of petroleum geology and explained the use of various oil-prospecting techniques. To achieve success in the world-wide search for oil it is desirable to have the partnership of geologist and geophysicist.

Mr O'Brien dealt with the case-history of several Middle East oil wells, and discussed the problems encountered by the geologist in tracing the exact location of the oil-bearing reservoir rocks.

The evening was concluded with a series of stimulating questions from the members present. The points raised ranged from the reasons for the variation in the quality of Kuwait crude to the validity of the theory of the migration of continents.

London Branch AGM

The London Branch held its Annual General Meeting on 19 January at 26 Portland Place, London, W.1, with the chairman, A. W. Deller, presiding.

The chairman's report and the accounts were adopted, and the meeting then elected new members of the Committee. Three of the existing Committee, A. W. Deller (chairman), W. H. Davies (vice-chairman), and a past chairman A. J. Goodfellow were due to retire having completed three years' service since their last election. A. W. Deller and W. H. Davies offered themselves for re-election but A. J. Goodfellow, to everyone's regret, decided he would not stand again—the Branch will greatly miss his experienced counsel as he took the leading part in the establishment of the Branch after the war and has been active in one capacity or another on the Committee ever since. To replace him J. H. M. Clark was elected.

Finally the members were asked their views on continuing the supply of tea before meetings in the face of rising costs. The feeling was that in view of the lateness of dinner, some tea was essential and it was agreed to continue. The meeting was then formally terminated.

London Branch

Slides illustrating the development of the oil tanker from the sailing ship of the 1860's to the giant tankers of today were shown by E. H. Thompson, when he addressed a meeting on 19 January. The title of the talk was "Ocean Transportation of Oil" and Mr Thompson began by describing the first types of vessel which were used to carry oil.

In 1861 the first barrelled cargo of oil to be brought from the United States of America to Britain was carried by the 224-ton brig, *Elizabeth Watts* and this was followed by many other sailing ships carrying oil in barrels or cases. Quite different kinds of cargo, such as barley, coals, oranges, and china clay, were sometimes brought back.

In 1866, the *Gluckauf*, which is regarded as the prototype of the modern oil tanker, was launched. This was followed in 1888 by the *Standard*, the first tank steamer to be built in the U.S.A., but despite the advent of the steamer, sailing ships continued to carry oil well into the 1900's.

Among the slides shown by Mr Thompson were pictures of the *Iroquois* and the *Navahoe*, which were built in 1907. The *Iroquois*, carrying about 8800 tons of cargo, towed the *Navahoe* which was rigged as a six-masted schooner and carried about 9250 tons. The towing lines were approximately a quarter of a mile long. The two vessels made 148 Atlantic crossings between March 1908 and May 1917, at an average speed of 8·7 knots, and the experiment was a great success. In 1930, however, the *Navahoe* became a storage hulk in the Caribbean and the *Iroquois* was finally broken up in 1947.

Mr Thompson spoke of the great bravery and endurance shown by oil tanker crews during the second great war and then went on to discuss the construction of the most modern tankers.

In conclusion, Mr Thompson spoke of the type of men who go to sea in tankers and gave a brief review of the training required by navigation and engineering officers.

Two films, "We've Come a Long Way" and "Transatlantic Background," were shown at the end of the talk.

The vote of thanks was proposed by R. Sharp.

Persian Gulf Branch—Bahrain Sub-Area

At a meeting held on 25 October in the auditorium of the Bahrain Petroleum Company's School, R. E. de Mestre (*Associate Fellow*) gave a talk on "The Drilling of a Bahrain Well." This talk, which was primarily intended for those not familiar with drilling operations, was illustrated by models, drawings, photographs, and coloured slides.

Mr de Mestre described, in non-technical language, the drilling of a normal Bahrain Zone development well, in which, on account of peculiar conditions, special techniques are employed. The drilling is divided into three phases. In the first phase, the top 1500 feet of complete lost circulation zones are drilled using water, in the second the next 500 feet to above the main producing zones are drilled with mud, and lastly the producing zones are diamond cored or drilled to the final depth of about 2300 ft. In each of these phases, on account of the varying pressures encountered, casing or a liner and a "topping out" string are set.

Following the talk, Mr de Mestre showed a series of slides illustrating the equipment in use in the Bahrain field, and at the conclusion he answered a large number of questions put by the audience, which included visitors from Qatar.

Scottish Branch

The annual general meeting of the Branch was held in Edinburgh on 7 January.

Following the A.G.M. two papers were read—"Fire Fighting" by Mr James Glasgow and "Civil Defence" by Mr H. M. R. Auchterlonie.

Mr J. M. Caldwell, J.P., chairman of the Branch, welcomed the fire officers from various local authority fire services and Civil Defence volunteers, who had been invited to the meeting. In introducing Mr Glasgow he said that Mr Glasgow had been

in the oil refinery at Abadan for 24 years, and the greater part of that time he had been a senior member of the fire service. At present he was firemaster at Grangemouth Petroleum Refinery Ltd. He said Mr Auchterlonie was also well qualified to talk about Civil Defence, since during the recent war as a senior police officer he had a wide experience of Civil Defence. After the war he went to Germany with the Control Commission, and is now Civil Defence Officer for Scottish Oils Ltd. The talks were illustrated with lantern slides and films and Anglo-Iranian Oil Co. film "Rig 20" was also shown.

In dealing with fire fighting, Mr Glasgow discussed the principles applied in fighting oil fires, giving a brief description of past and present day procedure and illustrating the methods of operation.

The appliances described included portable extinguishers of various types, foam making branch pipes, mechanical foam generators, multiple jet inductors, foam towers, dry risers for oil storage tanks, fixed CO_2 installations for protection of power plants and sub-stations, and the latest mobile foam tenders.

Brief observations were made on slop over and boil over characteristics and rates of foam application to burning tanks. General regulations and precautionary measures in the handling and storing of petroleum products were described.

In his talk on Civil Defence, Mr Auchterlonie surveyed the necessity for Civil Defence, its origin, growth, and present position with special reference to the atomic bomb.

The invention of the aeroplane, and the use of poisonous gases by the Germans in the first world war were described and he then dealt with the Geneva Gas Protocol of 1925 and the authorization in the mid-1930's by the Government of the Air Raid Precautions Organization. The development of Civil Defence into its present position of Fourth Arm of Defence was more fully described.

In connexion with the atomic bomb, a brief summary was given of the three main forms of danger—heat, radioactivity, and blast—and their potentiality of causing damage and injury to property and persons. Protective measures were outlined and photographs of the scene following the explosion of an atomic bomb were exhibited.

Mr Caldwell thanked the speakers for their interesting and informative talks, and Mr. R. Crichton proposed a vote of thanks to the chairman.

South Wales

The fifth meeting of the Session of the South Wales Branch was held on 21 January at the Training Centre, National Oil Refineries Limited, under the Chairmanship of J. A. Green. A very large audience was present to hear Dr D. A. Howes, assistant general manager, National Oil Refineries Limited, give a talk on the organization of an oil company.

After indicating the growth of the world-wide petroleum industry in recent years, by quoting figures for crude oil production, Dr Howes then mentioned the principal oil companies participating in the oil business outside the Western Hemisphere and surveyed their operations in prospecting, oil production, refining, and marketing, with particular reference to the large companies operating under joint ownership.

Dr Howes then described the growth of Anglo-Iranian Oil Company in some detail, from the time that crude oil was discovered in Persia up to the present day, and concluded his talk by describing in general terms how a large integrated oil company operates, by describing the functions of the various departments and how they work together. The organization of such a company was illustrated by showing how a new discovery made in the research laboratories is translated to full scale operation in a refinery, and another example described was the planning, design, construction, and operation of a new refinery.

Following the talk a wide range of questions were raised, and J. K. Anthony proposed a vote of thanks for a most interesting address.

CADMAN MEMORIAL LECTURE

Mr C. A. P. Southwell, C.B.E., M.C., B.Sc., a past-president of the Institute and managing director of the Kuwait Oil Company Ltd., has accepted the invitation of the Council of the Institute to deliver the Fourth Cadman Memorial Lecture on 17 November 1954 at the Royal Institution, London, at 4.30 p.m. Following the lecture, the Cadman Medal will be presented to Mr Southwell.

RANDOM RECOLLECTIONS

The Editor apologizes to the author and to the readers of this article, which appeared on page 36 of the February issue, for an unfortunate transposition of certain paragraphs. The article should be started at the paragraph commencing "Cars! Cars! Cars!" and the first four paragraphs as printed should be read at the end of the article.

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TRADE LITERATURE, ETC.

Kellogg Ammonia Process

Details of operating features and economics of plant for the production of ammonia from such feeds as natural gas, hydrogen gas, and hydrogen-rich gas are given in a booklet available from the M. W. Kellogg Co., Chemical Process Division, 225 Broadway, New York 7, N.Y., U.S.A.

Bubble Trays

As a means of encouraging the use of British materials overseas, Metal Propellers Ltd., are issuing instruction pamphlets for their Glitsch "Truss-type" bubble trays in Spanish as well as in English. The instructions relate to the erection of the trays on site.

OCMC Specification for Electric Motors

Recently issued by the Oil Companies Materials Committee is their specification ELEC/1 for Standard Three Phase Squirrel Cage Electric Motors. Prepared by the Electrical Panel, the specification has been developed to unify the principal requirements for such motors for oil industry use.

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LARGEST ORTHOFLOW CRACKER

Under construction at the Philadelphia refinery of The Atlantic Refining Company by The M.W. Kellogg Company is the world's largest Orthoflow fluid catalytic cracker. The reactor will have a total throughput of 45,000 *barrels per day.*

U.K. Petroleum Trade in 1953

By **GEORGE SELL (Fellow)**

Total imports of crude petroleum and liquid refined products into the U.K. during 1953 were 10 7 per cent higher than in 1952 according to preliminary figures.* The bulk of the increase related to crude petroleum, the imports of which in 1953 were 12.7 per cent higher than in the previous year. In the case of the refined products the increase was 3.6 per cent.

From Table I it will be noted that the only refined products to be imported in larger quantities than in 1952 were "other spirit," lubricating oil, and gas oil. Except for paraffin wax, all imports of solid and semi-solid products were higher in quantity.

Expressed as percentages of total import, the proportions of the various oils are not materially different in 1953 to the figures for 1952. As set out in Table II, the main change is that for crude oil, which accounted for almost 80 per cent of the total import.

C.I.F. Values

It will be noted from Table I that in spite of an increase in total quantity there was a decrease of 7.1 per cent in the total value or a drop of £23,810,738. In Table III the c.i.f. values have been calculated on a unit basis, from which it will be noted that the reduced values applied to all oils except motor spirit. The most noteworthy decreases are: crude oil, 18.3 per cent; lubricating oil, 32.6 per cent; fuel and diesel oils, 20.7 per cent; "other sorts," 28.2 per cent.

Consigning Countries

Details are given in Table IV of the countries from which

TABLE I

QUANTITY AND VALUE OF U.K. PETROLEUM IMPORTS

	1953		1952		1951	
	Quantity 1000 *gal*	*Value* £	*Quantity* 1000 *gal*	*Value* £	*Quantity* 1000 *gal*	*Value* £
Crude petroleum	6,677,487	218,304,916	5,925,977	237,167,810	4,308,974	159,171,661
Motor spirit	505,958	33,048,023	507,964	32,319,151	1,039,852	59,164,971
Other spirit	84,280	4,863,279	50,173	3,165,090	51,187	3,121,527
Kerosine	387,256	19,313,392	403,030	21,914,586	503,008	25,133,076
Lubricating oil	111,543	9,189,511	109,186	13,330,676	111,488	14,257,099
Gas oil	299,890	15,208,892	210,443	11,585,422	395,341	19,024,522
Fuel and diesel oils	285,224	8,772,958	335,780	13,014,355	570,994	20,025,958
Other sorts	219	25,305	248	39,924	541	124,862
Total refined products	1,674,370	90,421,360	1,616,824	95,369,204	2,672,411	140,852,015
GRAND TOTAL	8,351,857	308,726,276	7,542,801	332,537,014	6,981,383	300,023,676
	Cwt		*Cwt*		*Cwt*	
Paraffin wax	285,038	897,197	456,766	1,551,399	1,170,831	4,463,596
Mineral jelly	183,494	499,910	124,961	384,121	212,581	684,616
Carbon black from natural gas	268,773	1,336,318	129,137	699,930	886,479	4,063,535
	Tons		*Tons*		*Tons*	
Natural asphalt and bitumen	61,556	767,392	56,889	7211,11	57,537	692,381

TABLE II

PERCENTAGE IMPORTS OF PETROLEUM INTO THE U.K.

	1953	1952	1951	1950
	Per cent			
Crude petroleum	79.9	78.6	61.7	46.8
Motor spirit	6.1	6.7	14.9	24.0
Other spirit	1.1	0.7	0.8	0.6
Kerosine	4.6	5.3	7.2	7.6
Lubricating oil	1.3	1.5	1.6	2.4
Gas oil	3.6	2.8	5.6	7.3
Fuel and diesel oils	3.4	4.4	8.2	11.3
	100.0	100.0	100.0	100.0

TABLE III

AVERAGE C.I.F. UNIT VALUES OF U.K. PETROLEUM IMPORTS

	1953	1952	1951	1950
		£ *per* 1000 *gal*		
Crude petroleum	32.69	40.02	36.94	31.35
Motor spirit	65.32	63.62	56.89	44.62
Other spirit	57.70	63.08	60.98	55.65
Kerosine	49.61	54.37	49.97	44.46
Lubricating oil	82.39	122.18	127.88	84.94
Gas oil	50.71	55.05	48.12	41.09
Fuel and diesel oils	30.76	38.76	35.07	25.89
Other sorts	115.53	160.97	230.80	456.80
Total, refined products	54.00	58.99	52.71	44.04
		£ *per cwt*		
Paraffin wax	3.15	3.40	3.81	3.29
Mineral jelly	2.72	3.07	3.22	2.43
Carbon black	4.97	5.42	4.36	4.15
		£ *per ton*		
Natural asphalt and bitumen	12.47	12.68	12.03	10.11

*Accounts Relating to Trade and Navigation of the United Kingdom, December 1953. London: HMSO, 12s 6d.

TABLE IV

COUNTRIES CONSIGNING PETROLEUM IN THE U.K.

Country and Product	1953	1952	1951
		Thousand gallons	
KUWAIT:			
Crude petroleum	4,048,834	3,362,717	*
IRAQ:			
Crude petroleum	1,672,134	1,044,130	144,566
NETHERLANDS ANTILLES:			
Crude petroleum	186,336	197,676	284,463
Motor spirit	101,389	147,854	407,895
Kerosine	206,769	210,907	261,614
Lubricating oil	19,446	14,114	16,994
Gas oil	15,603	12,851	42,702
Fuel and diesel oils	102,117	91,560	226,733
	631,660	674,962	1,240,401
BAHRAIN, QATAR, AND TRUCIAL OMAN:			
Crude petroleum	416,450	210,933	2,229,632†
Motor spirit	41,935	28,347	59,725
Kerosine	11,451	5,707	11,573
Gas oil	17,109	10,418	29,205
	486,945	255,405	2,330,135
UNITED STATES OF AMERICA:			
Crude petroleum	30,080	22,016	25,581
Motor spirit	97,461	121,561	236,978
Kerosine	14,045	44,176	66,044
Lubricating oil	75,326	89,345	88,563
Gas oil	151,988	107,080	105,314
Fuel and diesel oils	44,000	69,021	39,349
	412,900	453,199	561,829
TRINIDAD:			
Motor spirit	121,739	50,929	54,331
Kerosine	99,647	114,627	52,035
Gas oil	35,348	16,887	26,122
Fuel and diesel oils	89,378	28,098	46,976
	346,112	210,541	179,464
VENEZUELA:			
Crude petroleum	217,697	149,419	104,585
Motor spirit	464	16,074	137,235
Kerosine	16,657	18,171	28,995
Gas oil	34,204	15,490	116,053
Fuel and diesel oils	11,627	8,085	13,272
	280,649	207,239	400,140
NETHERLANDS:			
Motor spirit	112,832	64,440	71,718
Gas oil	21,701	719	14,713
Fuel and diesel oils	19,867	63,993	47,871
	154,400	129,152	134,302
SAUDI ARABIA:			
Crude petroleum	58,530	880,998	1,005,867
PERU:			
Crude petroleum	30,256	35,204	36,010
FRANCE:			
Motor spirit	8,280	36,051	24,077
Gas oil	21,152	45,297	43,856
	29,432	81,348	67,933
BELGIUM:			
Motor spirit	15,457	37,861	3,746
Fuel and diesel oil	12,357	50,726	6,065
	27,814	88,587	9,811
SARAWAK:			
Crude petroleum	6,106	—	29,777
WESTERN GERMANY:			
Motor spirit	4,860	4,826	7,388
PERSIA:			
Crude petroleum	—	—	436,425
Motor spirit	—	—	35,867
Kerosine	—	—	80,753
Fuel and diesel oils	—	—	138,720
			691,765
MEXICO:			
Gas oil	—	—	17,324
OTHER BRITISH:			
Crude petroleum	31	—	—
Motor spirit	273	21	33
Kerosine	189	199	—
Lubricating oil	142	173	28
Gas oil	28	386	11
Fuel and diesel oil	1,281	2,611	25,903
	1,944	3,390	25,975
OTHER FOREIGN:			
Crude petroleum	11,033	22,884	12,068
Motor spirit	1,268	—	859
Other spirit	84,280*	50,173*	51,187*
Kerosine	38,498	9,243	1,994
Lubricating oil	16,629	5,554	5,903
Gas oil	2,757	1,315	41
Fuel and diesel oil	4,597	21,686	26,105
Other sorts	219*	248*	541*
	159,281	111,103	98,698

*Included with Bahrain, Qatar, and Trucial Oman.

†Including Kuwait.

*Includes also imports from British sources.

petroleum is consigned to the U.K., these countries not necessarily being the country of origin of the product. The most noteworthy points in the table are that Saudi Arabia, third largest supplier in 1952, was ninth in 1953, while the Bahrein group has risen from sixth to fourth.

The position of Kuwait in respect of supplies of petroleum to the U.K. is probably unique for, in 1953, it furnished nearly half of the total import of crude and refined products combined, and its quota of 4,048,834,000 gallons of crude oil represented 60.6 per cent of the total for that substance. The second leading importer was Iraq, with a quantity of crude oil equal to 25 per cent of the U.K. import of crude oil in 1953.

TABLE V

U.K. PETROLEUM IMPORTS BY ZONES OF CONSIGNMENT

	1953		1952		1951	
	Mil gal	*% of total*	*Mil gal*	*% of total*	*Mil gal*	*% of total*
Middle East	6,266	75.0	5,543	73.5	4,172	59.8
Caribbean and Peru	1,289	15.4	1,128	15.0	1,856	26.6
U.S.A. and Mexico	413	5.0	453	6.0	579	8.3
Europe	217	2.6	304	4.0	219	3.1
Undisclosed areas	167	2.0	114	1.5	154	2.2

In Table V the total imports of crude and refined products have been set out on a regional basis, and here again the importance of the Middle East is emphasized.

Re-Exports

Although in 1953, as shown in Table VI, the re-exports from the U.K. of imported petroleum were over three times greater than in 1952, the total of 21,461,000 gallons represented but a small proportion of the total import. In the case of bunkers

for steamers, including fishing vessels, there was an increase of 5.3 per cent in 1953.

Exports of Home-Produced Oils

An increase of 40 per cent in quantity and about 36 per cent in value in the exports of petroleum products of home production and manufacture, as shown in Table VII, continues the upward trend of recent years and is a reflexion of U.K. refining activity.

The changes in unit values in £ per 1000 gallons for the various products were: motor spirit £51.5 (£55.8 in 1952); kerosine, £50.9 (£54.7); lubricating oil, £162.1 (£178.7); gas oil, £42.5 (£46.7); diesel oil, £36.8 (£40.4); fuel oil, £27.7 (£29); all other sorts, £60.3 (£92.3).

TABLE VI

U.K. RE-EXPORTS OF IMPORTED PETROLEUM

	1953	1952	1951
	Thousand gallons		
Motor spirit	4,588	3,160	20,107
Kerosine	8,234	1,406	4,201
Lubricating oil	1,063	1,296	2,284
Gas oil	5,498	548	3,754
Fuel and diesel oils	1,981	10	1,530
All other sorts	97	185	293
TOTAL	21,461	6,605	32,169
Value	£1,304,250	£579,863	£2,233,634
Oil fuel shipped for use in steamers	857,618	814,566	699,579

TABLE VII

U.K. EXPORTS OF HOME-PRODUCED AND HOME-MANUFACTURED PETROLEUM

	1953		1952		1951	
	Quantity 1000 *gal*	*Value* £	*Quantity* 1000 *gal*	*Value* £	*Quantity* 1000 *gal*	*Value* £
Motor spirit	311,230	16,018,904	109,833	6,131,503	35,582	1,884,625
Kerosine	41,093	2,091,179	29,913	1,635,671	10,468	518,245
Lubricating oil	45,200	7,327,048	46,981	8,395,941	42,822	7,520,101
Gas oil	250,609	10,662,431	94,846	4,427,141	39,288	1,697,671
Diesel oil	136,079	5,007,949	139,737	5,647,087	76,943	2,832,327
Fuel oil	1,018,487	28,270,673	875,557	25,361,607	555,775	14,612,487
All other sorts	28,878	1,740,174	7,914	730,490	14,018	1,067,084
TOTAL	1,831,576	71,118,358	1,304,781	52,329,440	774,896	30,132,540
	Cwt		*Cwt*		*Cwt*	
Lubricating compounds	398,468	457,465	572,185	757,386	748,633	1,137,644
Manufactured bituminous asphalt and emulsions*	*Tons* 49,516	1,332,058	*Tons* 77,815	1,886,784	*Tons* 84,503	1,500,472

*Excluding material for use as paint and cable impregnating composition. The 1953 figures are not completely comparable with previous years.

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THE NEW MYTHOLOGY

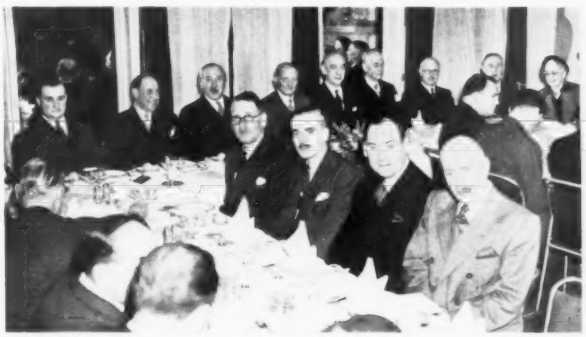
Bring me a Book of Olefinic Lore,
That I may read of Methyl Glucoside,
Of Butylene and Furfuraldehyde,
And Cacodyl's exploits in days of yore.
Tell me of Ester, calling from the shore
Her Aryl, nobly linked with Iodide,
With wanton Ethyl dancing at her side
While doughty Cetene stills the Halides' roar.
No double bond was sent to Hydrazone
To catalyze the soul of Aspirin,
When Allene, by the crystalline Quinone
Proclaimed his faith to golden Stearin.
But Eosin and warlike Erythrose
Returned to mock the gentle Levulose.

Disturb me not if Cumene should pass by,
Or Alkylate or Aldol seek their lair,
And Cyclohexane spread her sunlit hair
To tempt Vanillin; then his love deny.
Now Polypeptide sings her song on high,
While Isopentane hurtles through the air
To swoop on Benzidine all unaware
And stun the twilight with a Choline cry.
Nightly the homologues of Methane keep
Their hated watch upon the Glycine hill;
But not for Xylitol did Terpene weep
And Tetrahydroquinol curb his will.
So flows the Thymol to the vasty deep,
While in the vaulted skies the Ethers trill.

C.W.G.M.

REFINERY INSTRUMENTATION

Speaking at the recent annual luncheon of the British Industrial Measuring and Control Apparatus Manufacturers' Association in London, Mr Douglas Wilson, chairman of the Council of British Manufacturers of Petroleum Equipment, referring to the development in industrial instruments, said "Instruments in oil refineries almost think aloud. Your field is absolutely illimitable. But you must become aggressive. The intuitive genius of the Englishman is equal to that of anyone in the world."



Among those who were at the top table at the BIMCAM lunch were (left to right) *A. Smith (president of SIMA), W. G. Thomas (chairman of BIMCAM), Col Sir Harold Smith, K.B.E., D.L. (chairman of the Gas Council), H. W. Blake (president of BIMCAM), Douglas Wilson (chairman of CBMPE), W. G. Ardley (founder of BIMCAM), W. C. Knill (president, Institution of Water Engineers), H. W. Arkell (deputy chairman of BIMCAM), Miss H. V. Lupton (Ministry of Supply).*

Personal Notes

Sir Andrew Agnew, C.B.E., Hon.F.Inst.Pet., who resigned from the boards of The "Shell" Transport and Trading Co. Ltd and its associated companies on 1 January, had completed over fifty years with the Shell Group. His career began in 1903 in Singapore and during the last war he was in the responsible position of chairman of the Petroleum Board. He served as president of the Institute from 1946 to 1948 and all will join in wishing him a speedy recovery from the ill health which has caused his retirement.

An Esso Photo

Howard W. Page, shareholder's representative in London for Standard Oil Company (New Jersey) since 1949, has been appointed to that Company's board as from 1 January. He is chairman of Esso Transportation Company Ltd. and Esso Development Company Ltd. and from 1949 to 1952 was a director of Esso Petroleum Company Ltd. During that period he was also a director of the Iraq Petroleum Company Ltd. He was born in Berkeley, California, in 1906 and joined the Jersey Group in 1929 as a chemical engineer.

Peter T. Lamont, who has been appointed a director of the Standard Oil Company (New Jersey), has for several years been responsible for the co-ordination of the Company's world marketing activities. A graduate of the Massachusetts Institute of Technology, he joined the Group, as a clerk, in 1922.

R. H. Barker, F.C.I.S., secretary of London and Thames Haven Oil Wharves Ltd. has, in addition, now been appointed manager of the Company. He joined the Company as assistant secretary in 1939 and has been secretary since 1947. The position of general manager, held by the late E. A. Hunt until 1953, has been discontinued.

Harold Higinbotham, for many years technical director of Acheson Colloids Ltd., retired from active service on 31 December 1953 but retains a seat on the board. He joined E. G. Acheson Ltd. in 1925 and later became technical manager and in 1935 technical director.

Harold W. Fisher, who succeeds H. W. Page as shareholders' representative in the U.K. for the Standard Oil Company (New Jersey), joined the organization in 1927. After serving in various capacities in the research laboratories he was elected a director of Esso Standard Oil Company in 1945. In 1950 he was appointed refinery co-ordinator.

D. King-Farlow, M.B.E., M.A., LL.B., M.Inst.Pet., who has recently retired after twenty-eight years with the Shell Group, started with the old Roxana Petroleum Co. (now Shell Oil Co.). In 1930 he returned to the U.K. in the American Department of The Shell Petroleum Co. Ltd and after five years joined the Trade Relations Department. In 1950 he was transferred to the Distribution and Supply Department. During the war he attained the rank of Major on the staff of Combined Operations and was awarded the M.B.E. for saving life at sea.

Paul J. Anderson has been appointed deputy shareholders' representative in the U.K. for Standard Oil Company (New Jersey). He first joined the Group in 1934 and has held managerial positions in Brazil and Venezuela and was appointed president of the Standard Oil Company of Chile in 1946. He was president of Esso Standard (Near East) from 1948 to 1950 and since 1952 has been representing the Jersey interests on the board of the Iraq Petroleum Company and affiliated companies.

Dr G. M. Lees, M.C., D.F.C., Ph.D., F.G.S., F.Inst.Pet., F.R.S., has been awarded the Sydney Powers Memorial Medal of the American Association of Petroleum Geologists "in recognition of his distinguished and outstanding contributions to, and achievements in, petroleum geology."

W. F. Wackrill, formerly a managing director of Esso Transportation Company Ltd., has been appointed a director of Esso Petroleum Company Ltd. This change results from a reorganization by which the latter company reassumes direct control of its tanker fleet. Prior to joining the transport company in 1946, he had been with the Ministry of Shipping since its formation in 1939. In Esso Petroleum he will act as contact director for the new Marine Department.

G. W. Powell has been appointed manager of the Marine Department of Esso Petroleum Company Ltd., which will be responsible for management and operation of all deep sea vessels of that Company and of Esso Transportation Company. Previously he was Co-ordinator of Supplies and Shipping and has recently completed thirty years with the Company.

Air Commodore Sir Frank Whittle, British pioneer in jet propulsion, has joined the Bataafsche Petroleum Maatschappij in The Hague. He will give advice in the field of mechanical engineering in relation to techniques and equipment for the petroleum and petroleum-chemicals industries.

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NEW ANGLO-IRANIAN TANKERS IN 1954

Nine tankers, totalling 190,000 dw tons, are scheduled to be launched during 1954 for the Anglo-Iranian Oil Company's shipping organization, the British Tanker Company. Included in this number are three 32,000 dw ton tankers, five of 16,000 dw tons and one of 14,000 dw tons.

Thirteen 32,000-ton tankers have been ordered as part of the British Tanker Company's current building programme. One is already in commission and two more, which were launched in 1953, are scheduled for delivery early this year.

Three tankers, each 16,000 dw tons, are also to be launched during the year for the Lowland Tanker Company, in which the Anglo-Iranian Oil Company is in partnership with Common Brothers and Matheson and Company.

Chemical Engineering

PART VIII—SOLVENT EXTRACTION

By **D. C. FRESHWATER**

Introduction

Previous articles on distillation and absorption have shown how mass transfer between a liquid and a vapour is used to effect the separation of saleable products from petroleum. There is a third mass transfer operation closely related to the other two which has been largely developed by the petroleum industry and is widely used in the separation of mixtures of liquids. This operation is solvent extraction or liquid-liquid extraction, and was first applied commercially in the process developed by Edeleanu in which liquid sulphur dioxide is used to remove aromatic hydrocarbons from a kerosine in order to improve the latter's burning qualities. Later it was applied to the refining of lubricating oil, solvents being used to improve the viscosity-index by removing aromatic compounds or compounds of high C:H ratios. Other solvent refining processes are used to remove paraffin wax from lubricating oil and mercaptans from gasoline.

A detailed discussion of these and other processes using liquid extraction may be found in most standard texts on petroleum refining or in the references given later. This article is confined to consideration of the underlying principles of this unit operation. First, however, an important common factor of practically all extraction processes must be noted. The feed generally comprises a complex mixture of a number of pure compounds, some of which form a group of the desired chemical or physical type. These are separated by the solvent from the remaining group of compounds and, for design purposes, all the compounds in the group removed may be considered as one component and the other group of compounds as the second component. In order to simplify the discussion which follows, this idea is maintained throughout. It follows then that solvent extraction consists essentially of bringing a homogeneous liquid mixture of two components (the feed) into contact in a suitable apparatus with a second liquid (the solvent) which dissolves or extracts one component from the feed forming a new mixture (the extract). The extract contains the greater part of the original solvent and separates from that part of the feed which is not dissolved by virtue of a difference in density. Thus, two liquid layers are formed and that which contains the undissolved component of the feed is termed the raffinate. This idealized form of extraction is shown diagrammatically in Fig. 1. In practice, extraction

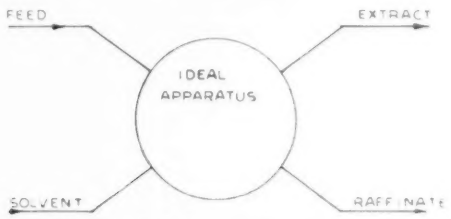

Fig. 1. Simple flow sheet of extraction process.

operations are almost always followed by distillation to separate the solvent from the extract and also to recover solvent in the raffinate since there are no completely immiscible pairs of liquids.

Liquid Equilibria

Although in practice complete mixing and equilibrium are not attained in solvent refining, nevertheless it is necessary first to consider the equilibria relationships between mixtures of partially miscible liquids such as are encountered in solvent extraction. These relationships are best shown on a simple phase diagram where composition is plotted against temperature. Fig. 2 shows such a diagram for the most simple case of a mixture

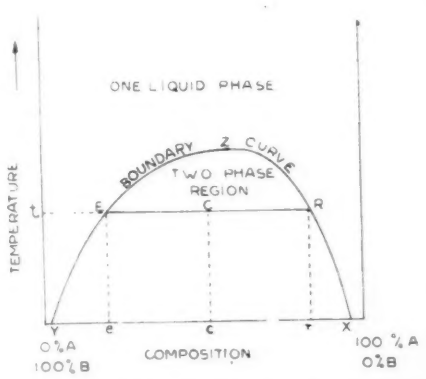

Fig. 2. Phase diagram for two-component mixture.

of two partially miscible liquids, A and B. Points on the curve XZY represent saturated solutions of A and B at various temperatures. The area above the curve represents mixtures which form a single liquid phase, i.e., they are completely miscible. Points below the boundary curve represent mixtures which form two mutually-saturated liquid solutions. Consider, for example, a mixture whose composition and temperature is represented by the point C. This will actually separate into two liquid phases, one of composition R and the other of composition E. The line R E is called a tie line and it will be shown that the relative weights of the two phases formed are inversely proportional to the lengths of the tie line segments, i.e.,

$$\frac{\text{The weight of R}}{\text{The weight of E}} = \frac{\text{CE}}{\text{RC}}$$

Consider 1 lb mole of the mixture *C*. Let the composition of this be *c* mole fraction of *A* whence there is $(1-c)$ mole fraction of B. This mixture will separate into two new mixtures, R and E, whose compositions in terms of mole fraction of *A* are *r* and *e* respectively. Let there be *x* moles of *R* and *y* moles of *E* formed. From an overall material balance:

$$x+y=1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

and in terms of component *A*

$$rx+ey=c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

From equation (1) $x=1-y$. Substitution for x in equation (2) gives $y=(c-r)/(e-r)$ .....(3)

Similarly, substitution of $(1-x)$ for y in equation (2) gives

$$x=(c-e)/(r-e)=(e-c)/(e-r)$$

The ratio y/x is equal therefore to

$$(c-r)/(e-c) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Inspection of Fig. 2 shows that this ratio is the same as the ratio of the lengths of the line segments *CR* and *EC*.

This is a convenient graphical method of determining material balances in extraction.

Consider now mixtures of three components A, B, and C. For the simplest case (which is also the one of most practical importance) the pairs of components AC and BC are miscible in all proportions but A and B are only very slightly miscible. Thus, the feed may be considered as a mixture of A and C, the solvent as B and the component to be extracted as C. The equilibria relationships for such a system at a constant temperature are usually shown as a diagram of the type of Fig. 3. Each apex

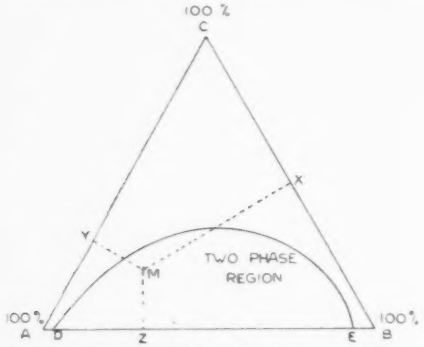

Fig. 3. Phase equilibria for three-component mixture.

of the triangle represents one of the components A, B, and C. Mixtures of A and B are therefore represented by points along the line AB and similarly mixtures of A and C along the line AC and B and C on BC. Any point inside the triangle represents a mixture of three components. Since the triangle is equilateral the composition of a mixture represented by a point inside it is in the ratio of the lengths of the three perpendiculars from the sides of the triangle to this point. Thus, for the point M, the composition of the mixture in terms of components A, B, and C is respectively MX, MY, and MZ. Note that the relative amount of any component is represented by the perpendicular length opposite to that component's apex. This can be seen by observing that since point A on Fig. 3 represents 100 per cent component A, any point away from it represents a mixture containing less than 100 per cent A. Moreover, the further the distance of this point from A, the less will be its percentage of component A and also the shorter the perpendicular from that point to the line CB.

In Fig. 3 points D and E represent saturated solutions of the binary mixture AB. All mixtures outside the boundary curve are miscible in all proportions whilst a mixture represented by a point inside the boundary curve such as M will form two insoluble liquid layers. The composition of such layers is represented by the points of G and H on Fig. 4 which also shows a few of the

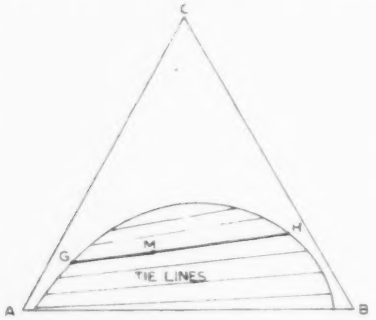

Fig. 4. A three-component diagram showing tie lines.

tie lines which are, of course, infinite in number. All mixtures along the line GH form two liquid layers of composition G and H. The relative quantities of each layer are in the inverse ratio of the tie line segments as with two component mixtures, e.g., M separates into MH of composition G and GM of composition H. The correct way of writing this relationship may easily be remembered by imagining a mixture, very rich in A, such that point M in Fig. 4 would lie very close to G. G is the A-rich and H the B-rich liquid layers which are formed from the mixture M. Since the original mixture was very rich in A, the A-rich layer that is formed will be clearly greater in quantity than the B-rich layer. But MH is much the longer tie line segment and therefore the weight ratio G/H is given by the ratio MH/GM. It should be noted that diagrams of the type shown in Figs. 3 and 4 are representations of the equilibria relationships at a single fixed temperature. For most three-component or ternary systems the area of heterogeneity and the slopes of the tie lines change with temperature and a complete phase diagram needs to be three-dimensional to show this. However, in most liquid-liquid extraction processes there is no heat effect involved other than heat of mixing and solution which is usually negligible in comparison with the enthalpy of the liquids. Hence, provided the temperature at each stage is known the two-dimensional ternary diagrams of the type illustrated can be used for design purposes.

Consider now how the most simple extraction process, i.e., single contact, may be represented on a ternary diagram. The flowsheet of the process is the same as Fig. 1 with the ideal apparatus replaced by a single stage. Referring to Fig. 5 the

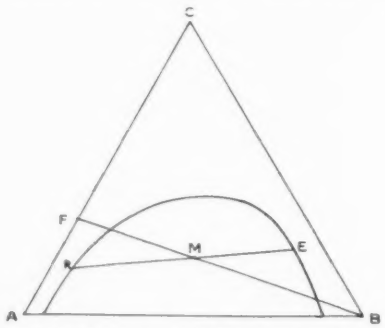

Fig. 5. Process of single-stage extraction represented on an equilibrium diagram.

feed mixture is represented by point F and the solvent by point B. Point M represents the composition resulting from the mixture of F and B (in the ratio BM to FB) and is located as explained earlier by a simple ratio of F to B along the tie line FB. It is clear from an inspection of Fig. 5 that there is both an upper and lower limit to the amount of solvent which can be used. If too much solvent is added point M will lie outside the boundary curve near B and so the mixture will be in the single phase region. Similarly with too little solvent point M will lie in the single phase region near F. The limiting amount of solvent is that which causes point M to lie on the boundary curve itself.

In a single ideal stage equilibrium is reached and the mixture M separates into two liquids of composition R and E where the line RME is a tie line through M. The quantities of raffinate R and extract E are found by ratio of the segments EM and MR. Clearly R is considerably less rich in component C than the original feed and so we have achieved a partial separation of C from the feed. If the raffinate is now removed from the apparatus and treated in a similar stage with fresh solvent of composition B, some of component C will again be extracted to produce a new raffinate R, still leaner in C. Such a process may be repeated several times and it is easy to imagine the separate

apparatus being interconnected so that it becomes a continuous flow process. This system is known as co-current multiple contact and is characterized by the solvent composition being the same at each stage. This process, however, is rarely used in practice. Instead, the feed and solvent enter at opposite ends of a battery of stages. Thus, the richest solvent contacts the material weakest in the component to be extracted whilst the near-saturated solvent contacts the liquid richest in the soluble component. That is to say, the driving force is maintained at a maximum throughout the apparatus. This produces a more concentrated extract and uses less solvent for a given feed, raffinate and number of stages than the previous process, and is known as countercurrent extraction. The flowsheet and composition changes are shown in Fig. 6 (a) and (b).

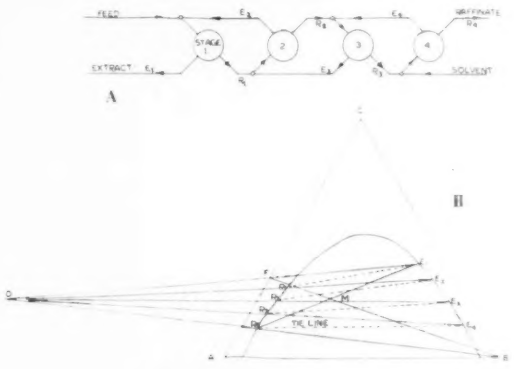

Fig. 6. Multi-stage extraction.

Referring to Fig. 6 (b), assuming that the feed and solvent compositions are fixed at F and B, then knowing the relative amounts of each fixes point M. If the desired composition of the final raffinate composition (in this case R_4) is known it can be shown that the final extract composition E_1 is the intersection of a straight line through R_4 and M with the boundary curve. This follows from an overall material balance on the system in Fig. 6 (a), which inspection shows to have only two materials, feed and solvent, entering from outside and only two leaving, final extract E_1 and raffinate R_4.

Four stages are shown in Fig. 6 but in general where the number of stages required to produce a given raffinate composition are not known, they may be found as follows. The raffinate in equilibrium with E_1 is clearly R_1 where E_1 R_1 is a tie line. E_1 F and BR_4 when extended meet at a point O outside the diagram (note that this point has constructional significance only). It can be shown that E_2 is given by the intersection of OR_1 extended, with the boundary curve. Again R_2 must lie on a tie line from E_2 and similarly E_3, etc., may be found.

It is clear from the construction of Fig. 6 (b) that if an extended tie line passes through the operating point O, the stepwise determination of stages could not pass beyond this tie line and in fact an infinite number of stages would be required even to reach it. This corresponds to the condition of minimum reflux in distillation processes. Since the line R_1B may not coincide with a tie line, the limiting position of O is found as follows: extend the line BR_4 outside the triangle; then extend a few typical tie lines so that they intersect BR_4 extended. The intersection which lies furthest away from the triangle is the limiting position of O since a point nearer the triangle would give rise to the impossible position referred to above. This construction actually determines the limiting amount of solvent since the further point O is from the triangle, the greater the amount of solvent which has to be used.

Modifications of this process are used in practice in which the feed usually enters the middle of an extraction battery and part of the extract and raffinate streams leaving each end are returned as "reflux" but consideration of these is outside the scope of this article.

So far ideal stages only have been considered. In practice equilibrium is not reached in each stage owing to incomplete mixing and finite time of contact and the efficiency of an actual stage is usually considerably less than 100 per cent. It is necessary, therefore, to use more stages in an actual apparatus than are indicated by design diagrams such as Fig. 6 (b). Before considering the apparatus which is used, however, it will be advisable to discuss briefly the mechanisms of mass transfer in extraction.

Equations were developed in the previous article on absorption showing that the rate of mass transfer per unit area was proportional to a driving force divided by a resistance. In extraction the same principle holds and again the driving force is a concentration difference whilst the resistance is imagined as due to films of stagnant liquid at the phase interface.

Inserting proportionality constants as before, gives:

$$N/A = k_R(x - x_i) = k_E(y_i - y)$$

where k_R is the raffinate film coefficient
k_E is the extract film coefficient
x is the concentration of soluble component in the raffinate
y is the concentration of soluble component in the extract,

and the subscript "i" refers to conditions at the interface.

Similarly, overall coefficients can be and usually are substituted for film coefficients (because of the difficulty of measuring liquid film coefficients) when the rate equation becomes:

$$N/A = K_R(x - x_e) = K_E(y_e - y)$$

where x_e is the concentration of x in the raffinate in equilibrium with a concentration y in the extract,
and y_e is the concentration of soluble constituent in the extract which is in equilibrium with a concentration x in the raffinate.

It will be noted that there is a close similarity between these relationships and those derived in the case of absorption. Similar expressions may be obtained for the processes involved in distillation and it is useful to remember that these three operations all involving mass transfer are basically the same. The difference in treatment of them arises largely as a matter of convenience of working methods for dealing with problems in the three fields.

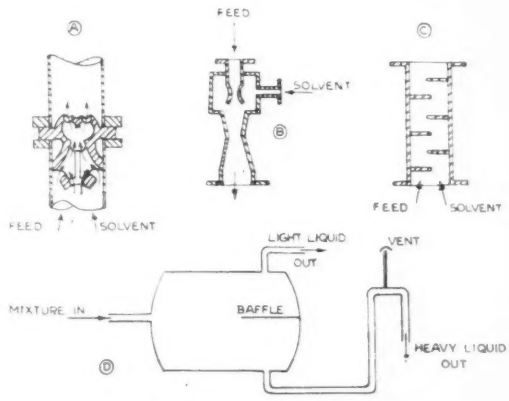

Fig. 7. Typical mixing devices and settler.

A. Simple in-line nozzle mixer.
B. Injector type mixer.
C. Simple in-line baffle plate mixer.
D. Simple gravity settler.

Consideration of the rate equations shows that an extraction apparatus should produce a large interfacial surface area between the two liquids being handled and at the same time promote a high degree of turbulence to reduce the film thickness and hence the resistance to mass transfer. However, the two phases produced by the mixing and mass transfer must be separated and this is almost always effected by allowing the mixture to stand or settle. In any continuous process the mixture can never become stationary but a settling tank is used large enough in comparison to the throughput so that the liquid velocity through it is very small and settling by gravity occurs. Thus, each stage in any apparatus consists essentially of a mixing device followed by a settling vessel. In older types of plant, conventional mixing devices such as jet mixers, injectors, and stirrers are used. Typical mixing nozzles are shown in Fig. 7, together with a conventional settling tank which would be used in conjunction with them. Many different designs of these mixer-settler types of apparatus are used but they are all basically the same. However, economic considerations make it desirable that the apparatus should handle a large throughput continuously and efficiently for the lowest possible capital cost. Mixer-settler type plants are costly in power and also take up considerable floor space. Much attention has been devoted in recent years to other more efficient types of apparatus and the present tendency is to replace mixer-settler batteries by single towers or columns similar to those used in distillation. The towers may be packed with stoneware rings or have plates of special design such as perforated plates or "Kaskade" plates, or they may simply contain a series of disk and doughnut baffles. A very promising development is a column of the last type in which the disk baffles are mounted on a central shaft and rotated whilst the unit is in operation. This is shown diagrammatically in Fig. 8 which also shows the connexions of feed solvent extract and raffinate for this type of plant. High stage efficiencies are claimed for such apparatus.

It is uncommon to find extraction processes operating in which more than five ideal stages are used, but since the efficiency of present day apparatus is very low, the equipment may be of considerable size.

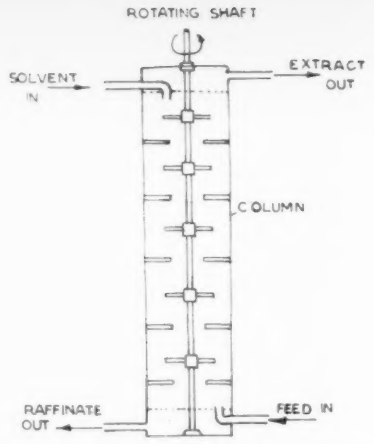

Fig. 8. Rotating disk type extraction column.

In conclusion it may be stated that although extraction is the most recent of the three principal mass transfer operations used in refineries, it is of growing importance and is proving a powerful tool to the chemical engineer in the more efficient processing of petroleum.

References for further reading:

Treybal, R. E., "Liquid Extraction," McGraw Hill Book Co., 1951.

Morello, V. S., and Poffenberger, N., *Industr. Engng. Chem.*, 1950, **42**, 1021–35.

Kalichevsky, V. A., and Stagner, B.A., "Chemical Refining of Petroleum," Reinhold Pub. Corpn., 2nd edition, 1942.

★ ★ ★

Books and Films

The U.K. Petroleum Industry

Just published by the Institute is "The Post-War Expansion of the U.K. Petroleum Industry," this being the full report of the Summer Meeting held at Buxton in June 1953. Included in the volume are the twelve papers which were read at the meeting and a full account of the discussion which followed.

The volume forms a comprehensive account of the present status and development of the petroleum industry in the U.K. All important aspects are discussed, including the oil sources and reserves of the Middle East, the transport of petroleum to the U.K., the construction and operation of refineries, the recovery of sulphur, chemical and other uses of hydrocarbon gases, and distribution and economic problems.

With a total length of 220 pages, the price of the book is £1 to members of the Institute of Petroleum and £1 5s to non-members. Copies may be ordered from the Institute by post.

Tanker Officers' Handbook

Designed to be a guide to the new officer in a tanker, Captain C. Baptist's book "Tanker Handbook for Deck Officers,"* presents much general and useful information. After dealing with tankship types and pumps and equipment, he proceeds to discuss the important aspects of preparing the ship to receive a cargo of crude oil, the operation of loading, and the discharging of oil.

Turning next to the carriage of refined petroleum products, the book discusses the order of loading when mixed cargoes are being carried and also suggests the special precautions to be taken when transporting lubricating oils.

The book concludes with a chapter on miscellaneous pumping data, and a folded chart of a T2 type tanker which includes trim tables and details regarding capacity of individual tanks. It is perhaps to be regretted that the author has not made it clear that the "gallons" in these tables are U.S. "gallons," as appears to be the case.

However, the book should be of value for the purpose for which it was written, i.e., to introduce the new officer to the intricacies of oil-handling in a tanker. G.S.

*Published by Brown, Son, and Ferguson Ltd, Glasgow, 1954, pp. 69. 10s. 6d.

Bahrain

The history, industry and life of the people of Bahrain are described and illustrated in an attractive booklet published by the Bahrain Petroleum Company Limited.

The booklet traces the development of Bahrain from the days when pearl diving was the main industry to the present day when over 6000 male Bahrainis are engaged in the oil industry in Bahrain.

Drilling for oil first began in October 1931 and within two years the oil field had been developed and a refinery had been built.

The growth of the oil industry since that time has had a striking effect, not only on the physical wellbeing of the people of Bahrain, but also on their intellectual life, and the booklet illustrates many of the changes in social and economic conditions which have come about since 1931.

Notes of the Month

Crude Oil Productions

	December 1953	*Jan. to Dec. 1953*
	Tons	*Tons*
Kirkuk—Iraq Petroleum Co. Ltd.	1,974,653	22,865,538
Zubair—Basrah Petroleum Co. Ltd.	307,046	3,077,522
Ain Zalah—Mosul Petroleum Co. Ltd.	98,361	1,277,139
Qatar—Qatar Petroleum Co. Ltd.	342,972	3,997,926
Kuwait—Kuwait Oil Co. Ltd.	3,983,242	42,603,244
	Brl	
Trinidad Petroleum Development Co. Ltd.	278,052	

Middle East Production

Total production of crude petroleum in Iraq by the Iraq Petroleum Co. Ltd. and associated companies in 1953 was 27,220,199 tons, an increase of nearly 51 per cent over the 1952 figure of 18,060,797 tons. The increase, due to the continued operation of the 30-inch pipeline outlet from Kirkuk to the Banias terminal, was largely from the Kirkuk field, production from which rose by 47 per cent from 15,552,715 to 22,865,538 tons. The Zubair field of the Basrah Petroleum Co. Ltd., showed an increase of 33 per cent, from 2,238,177 to 3,077,522 tons, and the Ain Zalah and Butmah fields of the Mosul Petroleum Co. Ltd., which are now connected to the 30-inch line, produced nearly five times as much oil as in 1952—1,277,139 tons in 1953 compared with 269,503 in the previous year.

In Qatar also there was a 23 per cent increase in production in 1953, the comparative figures being 3,997,926 tons in 1953 against 3,245,343 tons in 1952.

Kuwait

Production of crude oil by the Kuwait Oil Co. Ltd., in Kuwait, the largest producing field in the Middle East, was 42,603,244 tons in 1953. This is an increase of about 15 per cent over the 1952 total of 37,042,122 tons.

AIOC Refinery Throughout

Provisional figures issued by the Anglo-Iranian Oil Co. show that the company's refineries in the United Kingdom processed during 1953 approximately 2,500,000 tons more oil than in 1952. The throughput figures issued for the two years are 9,100,000 tons in 1953 and 6,600,000 tons in 1952.

At the refineries' shipping terminals in South Wales, Scotland, and Kent a total of 2557 tankers were handled in 1953. Of this number 737 discharged oil and 1820 loaded products, including 371 vessels which sailed for overseas ports.

Rise in Exports of Petroleum Equipment

Preliminary details for exports of oil refinery and drilling equipment from the U.K. during 1953 show considerable increases over the previous year. Available figures are:—

	1953		1952	
	Quantity	*Value*	*Quantity*	*Value*
	Cwt	£	*Cwt*	£
Mineral oil refining machinery	156,384	2,257,950	100,238	1,634,772
Petroleum well drilling machinery	97,417	2,546,923	84,685	2,176,738

U.K. TEL Exports

Exports of tetraethyl lead from the U.K. during 1953 amounted to 1,084,935 gallons, valued at £2,502,312. In quantity this was an increase of 18·9 per cent over the 1952 total of 963,004 gallons, and in price 9·7 per cent over the £2,281,657 for 1952.

British Oil Search

Further success in their search for oil at Plungar, near Nottingham, is reported by the D'Arcy Exploration Company (the Anglo-Iranian Company's prospecting subsidiary). Traces of oil have been found at a depth of 2891 ft in the Company's second well and tests are now being made to ascertain the quantity of oil in the stratum.

Oil is already being produced at the rate of approximately four tons a day from a well one thousand feet away from the present test site.

The site has been chosen for a third test well at Plungar, but drilling will not begin until the results of tests at the second well are known.

U.S. Pipeline Mileage

At the beginning of 1953 the total mileage of oil pipelines in the United States was 170,423 miles, made up of 75,228 miles of crude trunklines, 27,155 miles of products trunklines, and 68,040 miles of gathering lines. Details are given in U.S. Bureau of Mines Information Circular 7671* and the data in Table I on mileage by pipe sizes is extracted therefrom. During the three years 1950-2 a total of 31,873 miles of pipe was laid, 23,145 miles being new pipe, representing nearly 2 million tons of steel, and 8728 miles being used pipe. The amount taken up was 14,264 miles, making the net increase 17,609 miles.

The pipeline fill of the crude trunk and gathering lines was 50,021,000 barrels, or 18 per cent of crude storage at the end of 1952. For the products lines, the fill was 9,884,000 barrels.

TABLE I

U.S. OIL PIPELINE MILEAGE BY SIZES, 1 JANUARY 1953

Size inches	*Crude trunklines*	*Mileage Products trunklines*	*Gathering lines*	*Total*
2	—	—	17,724	17,724
3	1,173	385	10,707	12,265
4	3,276	1,485	25,449	30,210
6	11,538	7,348	10,379	29,265
8	26,961	11,712	3,174	41,847
10	13,476	2,552	468	16,496
12	9,511	2,621	117	12,249
14	354	542	16	912
16	1,603	77	4	1,684
18	1,423	433	1	1,857
20	2,959	—	1	2,960
22	2,345	—	—	2,345
24	596	—	—	596
Over 24	13	—	—	13
TOTAL	75,228	27,155	68,040	170,423

*Crude-oil and refined-products pipeline mileage in the United States, January 1, 1953." A. T. Coumbe and I. F. Avery.

Australian Oil Search

It was recently announced in Melbourne that the Frome-Broken Hill Co. Pty. Ltd., which was formed in 1946 to explore for oil and gas in Australia, is to increase its capital to £A1,000,000 in order to intensify its search.

Shareholders of the Company are the D'Arcy Exploration Co. Ltd. (a subsidiary of the Anglo-Iranian Oil Co. Ltd.), the Zinc Corporation Ltd. (one of Australia's largest mining companies), and the Vacuum Oil Co. Pty. Ltd. (a subsidiary of the Standard-Vacuum Oil Co.).

Since the Frome-Broken Hill Company was formed, extensive geological and geophysical work has been carried out over wide areas in Victoria, South Australia, Western Australia, and the Northern Territory, and a vast amount of valuable geological information has been accumulated.

Fire in the Bristol Channel

An Anglo-Iranian Photo

The fire-fighting tug *Nirumand* from the tanker terminal of Anglo-Iranian's Llandarcy Refinery, played a major part in extinguishing the fire which broke out in the Admiralty auxiliary tanker *Wave Victor* in the Bristol Channel on 17 January.

The fire broke out at 5.24 p.m. *Nirumand* went to the tanker's aid from Swansea and fought the fire all night and during the following morning until it was extinguished. With other tugs, *Nirumand*, left in this photo, escorted *Wave Victor* into King's Dock, Swansea.

Nirumand can direct foam or water, or a mixture onto a fire. Two diesel pumps on deck and one steam pump in the engine room give a total water capacity of 3900 gallons a minute (1044 tons an hour). Foam capacity is 3350 gallons. Four mechanical foam generators each take 14 gallons per minute of foam and 350 gallons per minute of water, the mixture giving an output of 2450 gallons per minute of foam. Total output of foam mixture is thus 9800 gallons per minute. Eight gear-operated monitors are fitted on the bridge in such a position that they can be pointed in any direction.

QUOTATION

"Their chance comes when they (Marilyn Monroe, Lauren Bacall, and Betty Grable) are invited . . . to attend a reception at the Oil Institute! We must admit that at this point we found ourselves wishing that the Institute of Petroleum would enlarge its guest list in a like manner, for we recalled several functions there which would have been considerably enlivened by the presence of such luscious creatures." From *The Shell Magazine* review of the film *How to Marry a Millionaire*.

Forthcoming Meetings

THE INSTITUTE

(*At* 26 *Portland Place, London, W.*1, 5.30 *p.m.—tea* 5 *p.m.*)

Symposium on Metal Working Oils. At the Institution of Electrical Engineers, 2.15 p.m. **19 March**

The Design and Manufacture of Welded Pressure Vessels. T. B. Webb, B.Sc., M.I.Mech.E., M.A.S.M.E. **14 April**

IP FAWLEY BRANCH

(*At Esso* (*Fawley*) *Recreation Club, Holbury*, 7.30 *p.m.*)

Corrosion Problems. W. E. J. Lewis. **12 March**

Motor Racing. Captain George Eyston. **9 April**

IP LONDON BRANCH

(*At* 26 *Portland Place, London, W.*1, 6 *p.m.—tea* 5.30 *p.m.*)

Careers in the Petroleum Industry. E. L. K. Frost. **17 March**

Engine Design as Influenced by Fuels and Lubricants. C. A. Beard, A.M.I.Mech.E., A.F.R.Ae.S., and D. Downs, B.Sc., A.M.I.Mech.E., A.F.Inst.Pet. (At the Institution of Mechanical Engineers, 6.30 p.m.). **1 April**

IP NORTHERN BRANCH

(*At Engineers' Club, Albert Square, Manchester* 2, 6.30 *p.m.*)

Natural Oils, Fats, and Waxes. **16 March**

Automatic Instrumentation in the Petroleum Industry. **20 April**

IP SCOTTISH BRANCH

Gas Turbines. J. R. Bolter. Institute of Engineers and Shipbuilders, Glasgow. **11 March**

IP SOUTH EASTERN BRANCH

(*At King's Head Hotel, Rochester*, 7.45 *p.m.*)

Industrial Relations in the Oil Industry. C. A. Tucker. **6 April**

IP ECONOMICS AND OPERATIONS GROUP

Staff Communications. E. L. K. Frost. At 26 Portland Place, London, W.1, 5.30 p.m. **23 March**

IP STANLOW BRANCH

(*At Grosvenor Hotel, Chester*, 7.30 *p.m.*)

Refinery Operational Programming. A. N. Holmes, M.A., M.Inst.Pet. **17 March**

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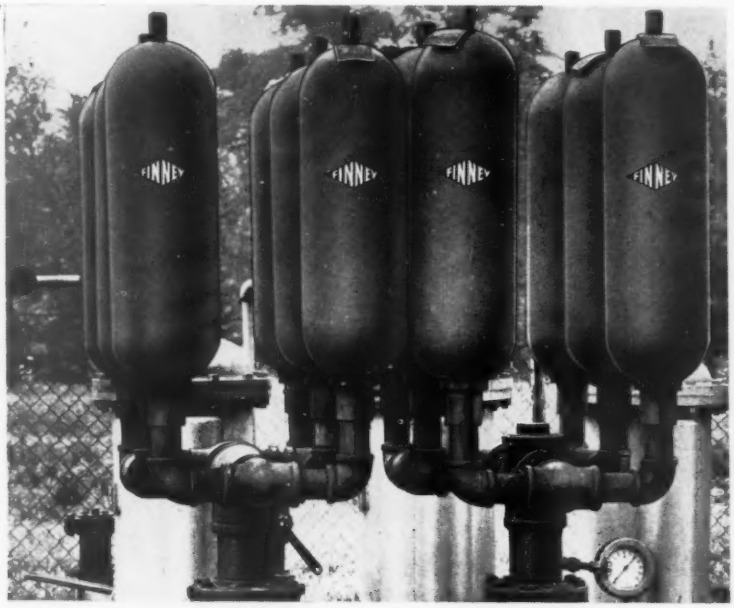

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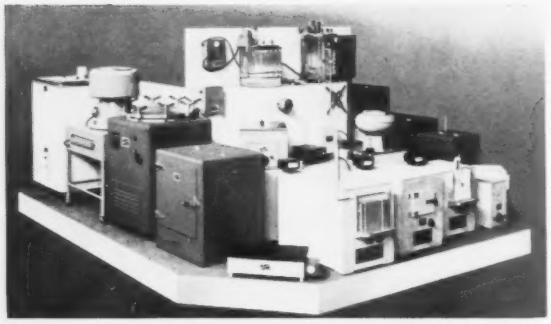

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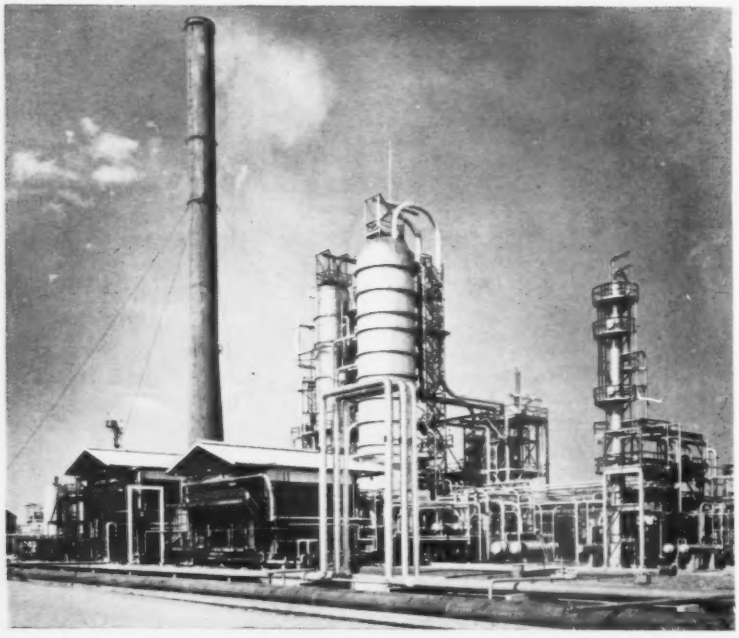

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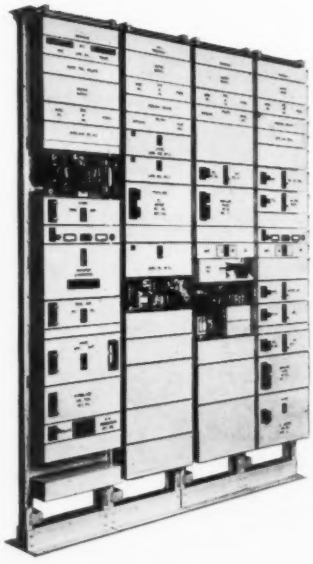

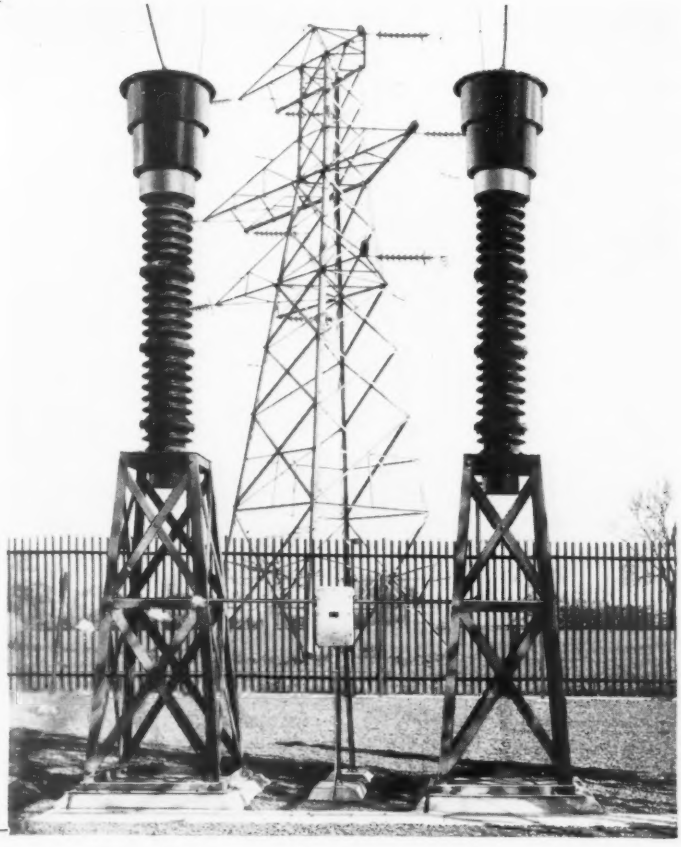

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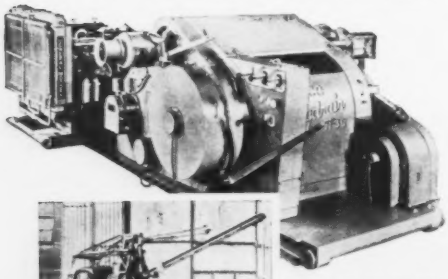

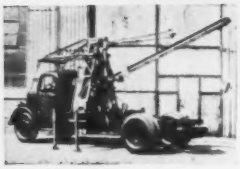

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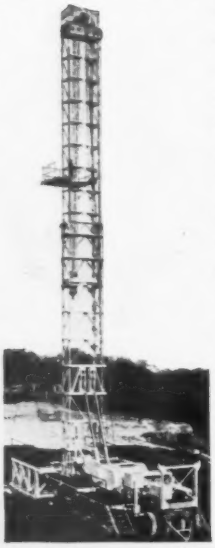

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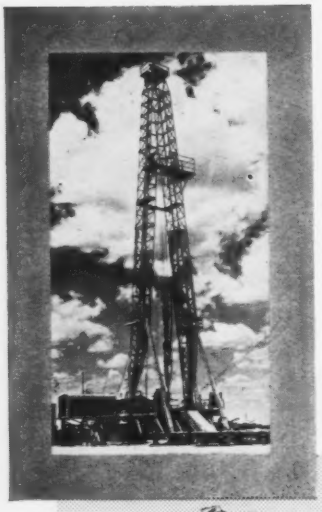

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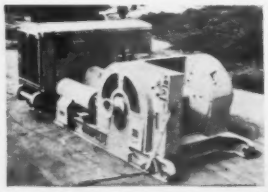

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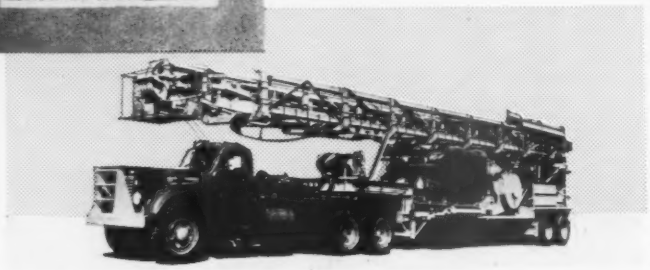

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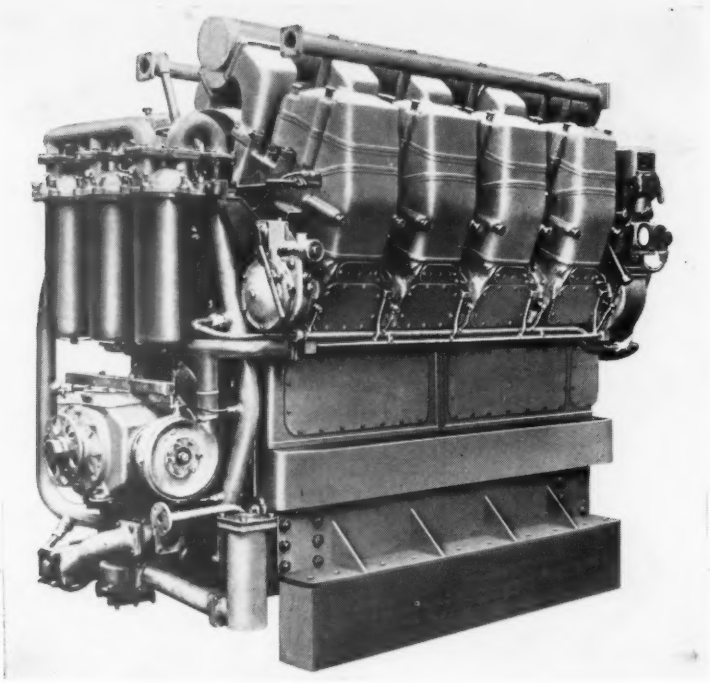
668 B.H.P. type 8V 'Package Unit'



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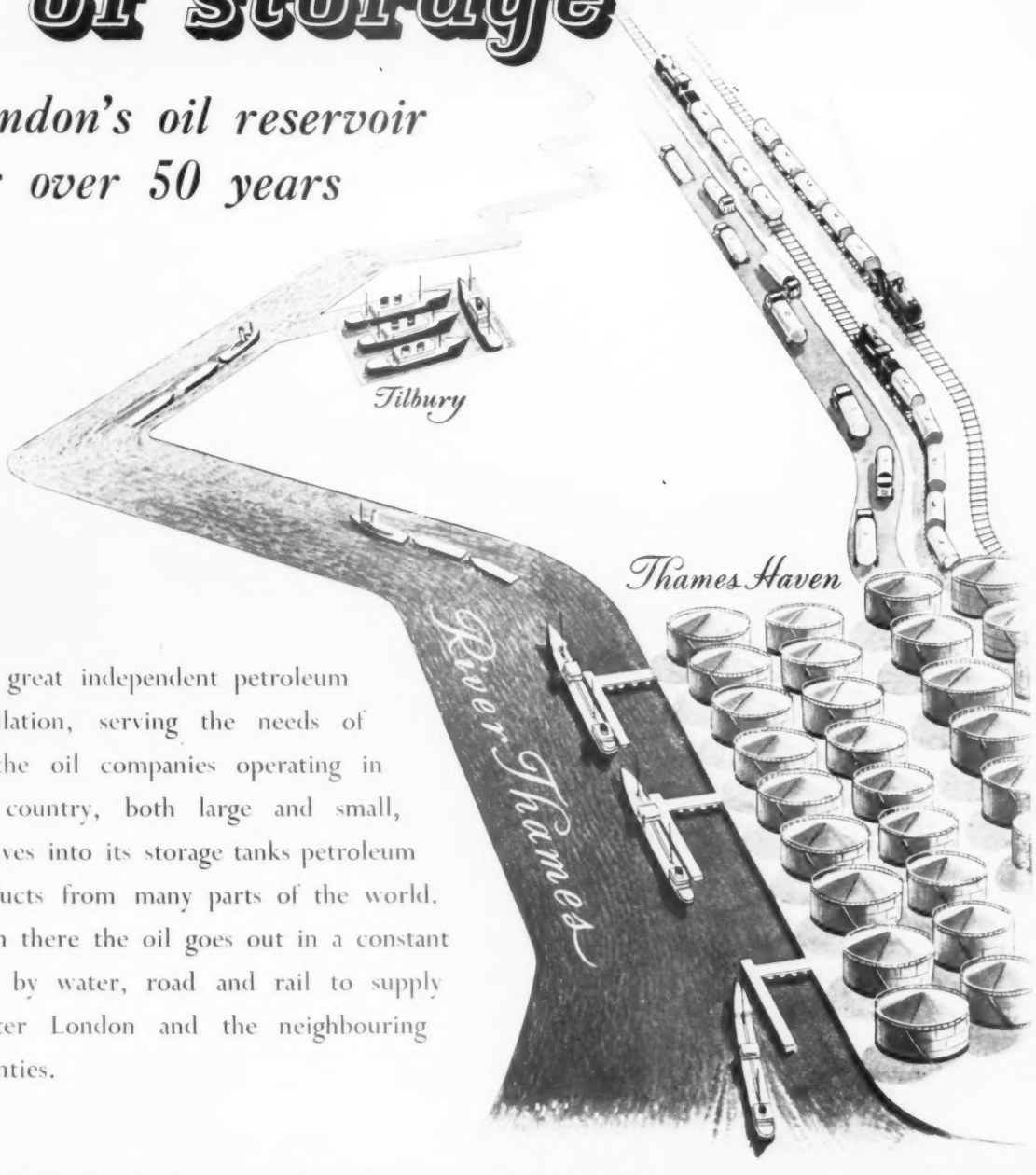

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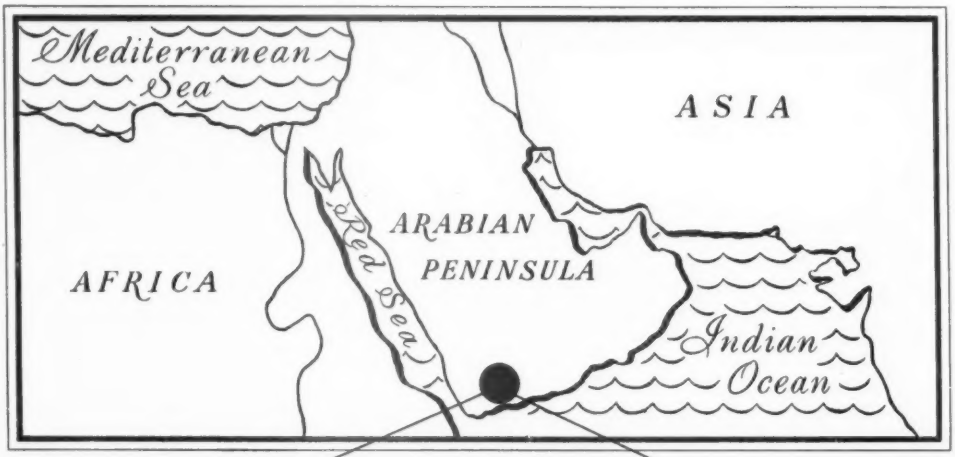
REFINERY PROJECT



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Barrel per stream day
topping units

One 8,150
Barrel per stream day
SO_2 extraction unit

One 8,000
Pounds per day
SO_2 production unit

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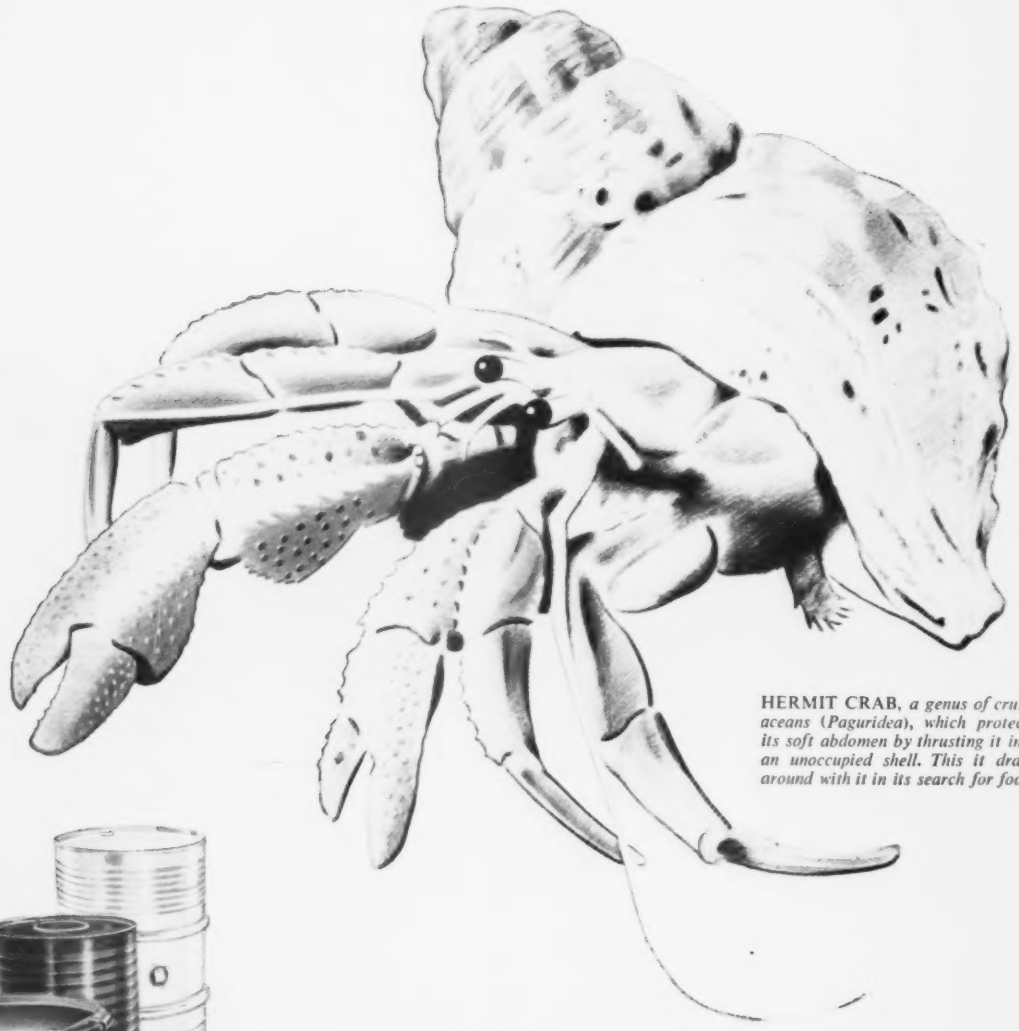
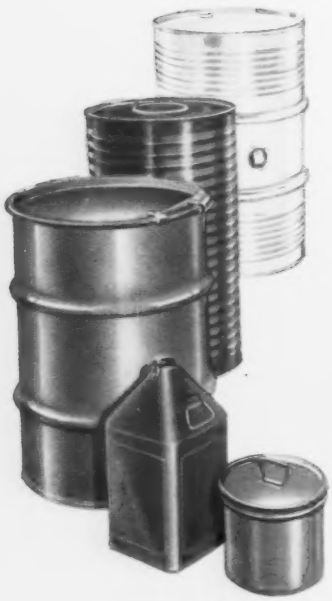


HERMIT CRAB, *a genus of crustaceans (Paguridea), which protects its soft abdomen by thrusting it into an unoccupied shell. This it drags around with it in its search for food.*



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